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## Just Piping

I AM all about you. Up above, where you never notice me until I spill hot water down your neck; head high so that you duck in passing, or forget to duck and mutter (?) your comment; hidden in walls and floors beyond your most watchful inspection; in dirty corners where valves are never tested or touched except when needs must; I am black and greasy. I am "Just Piping."

I am spotless, with shining bands; I am brilliant with polishing and shining with fresh paint; I am of the colors of the rainbow according to my task; I stand where all may see and admire; my valves and joints are perfect; I am your care and pride. But I am "Just Piping."

I carry your willing giant Steam to his endless task; I feed your thirsting boilers the flood essential to their power; I bring to your rooms the warmth of the South; I bathe your flying, whirling bearings with soothing anointment of oils; I blow into your drills and hoists their breath of life; I cool you in the heated days and form for your comfort the sparkling ice. Still I am "Just Piping."

And if I fail you;—Where is the power of your giant engines? What use your boasted monster teakettles? You shiver; the busy wheels are stilled; drills are silent; hoists drop their burdens; and your throats parch for the cold water. Yet, I am "Just Piping."

Consider these things, and think on the message that you herein find.

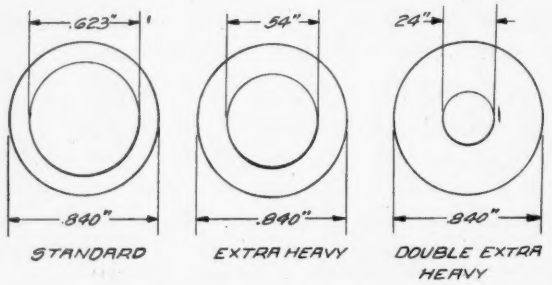
# Piping Materials

SHORT HISTORIC SKETCH; MATERIALS USED AND THEIR CHARACTERISTICS; PIPE DIMENSIONS

IN THE EARLY AGES of man's endeavor to solve the problems of existence, various forms of pipe were utilized for the conveyance of fluids.

In the tropical countries, "bamboo" was largely used. Excavations in Egypt and South America bring to light the "pottery" tubes of prehistoric ages. Lead pipe and bronze faucets recovered from the ruins of Italy and Greece show the first examples of metallic piping. Hollow logs were extensively employed in wooded regions.

After the invention of gunpowder, the first cannons were made of bronze, and the early Spanish cannons are skillful examples in the metal-working art. Later, in the manufacture of gun barrels, bronze proved too expensive, and the search for a cheaper material brought out the earliest application of wrought iron for tubes. The early piping systems of England consisted of a succession of gun barrels.




DIMENSIONS OF A ½-IN. STEEL OR WROUGHT-IRON PIPE

In the early history of wrought iron tubes, which has its origin in Europe, the only well-known method consisted of bending an iron plate to form a rolled strip or skelp, and the edges were welded together piecemeal by hammering the red-hot metal over a rod or mandrel. The subsequent discovery of coal gas for lighting made imperative the development of a more perfect pipe which at the same time could be manufactured with greater facility. Many ingenious and labor-saving devices for pipe manufacture were introduced, and with the present modern processes about 3,000,000 tons of pipe are produced annually in the United States.

## Steel Piping

MILD STEEL, wrought iron, cast iron, brass, and copper are the materials commonly employed in the manufacture of pipe for power and heating service.

Formerly wrought iron was favored for the best class of work, on account of its greater ductility and resistance to corrosion as compared with steel. Improvements in the manufacture of steel have now made it virtually equal to wrought iron for general piping work, and owing to its lower cost, it is now used extensively. Comparisons of modern wrought iron and steel pipe in the same lines of service have shown that where corrosion is found, one material suffers, on the average, as much as the other.

Steel for pipes is commonly made by the open-hearth or Bessemer process, giving a tough and strong quality of metal, similar to boiler plate. It should have an ultimate tensile strength of about 60,000 lb. per square inch.

## Factors in Pipe Durability

PHYSICAL PROPERTIES of pipe are often as important to its life as its resistance to corrosion. This is especially the case in high pressure steam, compressed air, ammonia and gas lines.

The life of all pipe must depend largely on service conditions. No matter how well any certain grade of pipe may resist rust, its life may be short if it is liable to crystallization and fracture from vibration, expansion, shocks, and other stresses, or if the welds are not uniformly reliable, or the threads or joints lack strength.

Bursting steam and water pipes and leaky gas and ammonia pipes are today the source of so many accidents and so much property damage that too much emphasis cannot be laid on the physical properties of pipe. As a rule, such accidents are accepted as the inevitable, while physical defects in the pipe used, or inherent weaknesses in the material from which it is made are really to blame.

Steel and wrought iron pipe is usually graded as "Standard," "Extra Heavy" and "Double Extra Heavy," the thicknesses and weights increasing progressively. Variation in weight should not be more than 5 per cent from the specified standards.

Pipes up to 12 in. in size are designated by the nominal inside diameters; those above 12 in. are specified by their actual outside diameters. No established grading exists for these larger pipes. For ordinary service, they are made ⅜ in. thick; for heavy service, the 14 and 15-in. sizes are 9/16 in. thick; the 16, 18, 20 and 22-in. are ⅝ in. thick; and the 24-in. pipe is 11/16 in. thick. All pipes larger than 12 in., and all sizes of extra heavy and double extra heavy pipe, are furnished, unless otherwise ordered, with plain ends, without threads or couplings. Smaller sizes of standard pipe are threaded and coupled. Changes in thickness and weight of the various grades are made by varying the inside diameter only. The outside diameter remains constant so that any grade of pipe may be treated in any grade of fitting, flange, coupling or valve. Dimensions of ½-in. steel or wrought-iron pipe are shown herewith.

Standard-weight is commonly used for heating work, exhaust lines and all pressures below 100 lb. per square inch, but for pressures from 100 to 200 lb., extra heavy pipe should be employed. When particularly exposed to corrosion, it is well to use extra-heavy pipe. This applies to blowoff connections to boilers, feed lines, sealed returns, underground drip piping, etc., and all lines that are to run in places that are not easily accessible.

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Tests show the actual bursting strength of mild steel pipe from 2 to 6 in. in diameter to range from 5000 to 3000 lb. per square inch, and it is commonly subjected to a hydrostatic pressure at the mills of 500 to 1000 lb. Extra heavy and double extra heavy pipe is tested to a maximum pressure of 1500 lb. Special hydraulic pipe, for service on lines requiring the highest possible grade of material and workmanship, are bored from solid forgings and are made to order for pressures up to 10,000 lb. per sq. in.

For calculating the bursting point of pipe of given thickness the generally accepted formula is:

$$\text{B. P.} = \frac{2t \times \text{T S}}{\text{D}}$$

where B. P. = bursting pressure; t = thickness; D = internal diameter; T S = tensile strength of material; all dimensions in inches.

TABLE I. DIMENSIONS OF STANDARD WROUGHT PIPE

| Diameter | | | Nominal Thickness | Circumference | | Length of Pipe Per Sq. Ft. Of | | Length of Pipe Containing One Cu. Ft. | Nominal Weight Per Foot | | Number of Threads Per Inch of Screw | Length of Perfect Screw |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nominal Internal | External | Approximate Internal | | External | Internal | External Surface | Internal Surface | | Plain Ends | Threaded and Coupled | | |
| Inches | Inches | Inches | Inches | Inches | Inches | Feet | Feet | Feet | | | | |
| 1/8 | 0.405 | 0.269 | 0.068 | 1.272 | 0.845 | 9.431 | 14.199 | 2553.770 | 0.244 | 0.245 | 27 | 0.19 |
| 1/4 | 0.540 | 0.364 | 0.088 | 1.696 | 1.144 | 7.073 | 10.493 | 1383.790 | 0.424 | 0.425 | 18 | 0.29 |
| 3/8 | 0.675 | 0.493 | 0.091 | 2.121 | 1.549 | 5.658 | 7.747 | 754.360 | 0.567 | 0.568 | 18 | 0.30 |
| 1/2 | 0.840 | 0.622 | 0.109 | 2.639 | 1.954 | 4.547 | 6.141 | 473.910 | 0.850 | 0.852 | 14 | 0.39 |
| 3/4 | 1.050 | 0.824 | 0.113 | 3.299 | 2.589 | 3.637 | 4.635 | 270.030 | 1.130 | 1.134 | 14 | 0.40 |
| 1 | 1.315 | 1.049 | 0.133 | 4.131 | 3.296 | 2.904 | 3.641 | 166.520 | 1.678 | 1.684 | 11-1/2 | 0.51 |
| 1-1/4 | 1.660 | 1.380 | 0.140 | 5.215 | 4.335 | 2.301 | 2.767 | 96.275 | 2.272 | 2.281 | 11-1/2 | 0.54 |
| 1-1/2 | 1.900 | 1.610 | 0.145 | 5.969 | 5.058 | 2.010 | 2.372 | 70.733 | 2.717 | 2.731 | 11-1/2 | 0.55 |
| 2 | 2.375 | 2.067 | 0.154 | 7.461 | 6.494 | 1.608 | 1.847 | 42.910 | 3.652 | 3.678 | 11-1/2 | 0.58 |
| 2-1/2 | 2.875 | 2.469 | 0.203 | 9.032 | 7.757 | 1.328 | 1.547 | 30.080 | 5.793 | 5.819 | 8 | 0.89 |
| 3 | 3.500 | 3.068 | 0.216 | 10.996 | 9.638 | 1.091 | 1.245 | 19.480 | 7.575 | 7.616 | 8 | 0.96 |
| 3-1/2 | 4.000 | 3.548 | 0.226 | 12.566 | 11.146 | 0.954 | 1.076 | 14.560 | 9.109 | 9.202 | 8 | 1.00 |
| 4 | 4.500 | 4.026 | 0.237 | 14.137 | 12.648 | 0.848 | 0.948 | 11.310 | 10.790 | 10.889 | 8 | 1.05 |
| 5 | 5.563 | 5.047 | 0.258 | 17.477 | 15.856 | 0.686 | 0.756 | 7.198 | 14.617 | 14.810 | 8 | 1.16 |
| 6 | 6.625 | 6.065 | 0.280 | 20.813 | 19.054 | 0.576 | 0.629 | 4.984 | 18.974 | 19.185 | 8 | 1.26 |
| 7 | 7.625 | 7.023 | 0.301 | 23.955 | 22.063 | 0.500 | 0.543 | 3.717 | 23.544 | 23.769 | 8 | 1.36 |
| 8 | 8.625 | 8.071 | 0.277 | 27.096 | 25.356 | 0.442 | 0.473 | 2.815 | 24.696 | 25.000 | 8 | 1.46 |
| 9 | 9.625 | 8.941 | 0.342 | 30.238 | 28.089 | 0.396 | 0.427 | 2.294 | 33.907 | 34.188 | 8 | 1.57 |
| 10 | 10.750 | 10.192 | 0.279 | 33.772 | 32.019 | 0.355 | 0.374 | 1.755 | 31.201 | 32.000 | 8 | 1.68 |
| 11 | 11.750 | 11.000 | 0.375 | 36.914 | 34.558 | 0.325 | 0.347 | 1.515 | 45.557 | 46.247 | 8 | 1.77 |
| 12 | 12.750 | 12.090 | 0.330 | 40.055 | 37.982 | 0.299 | 0.315 | 1.254 | 43.778 | 45.000 | 8 | 1.87 |
| 13 | 14.000 | 13.250 | 0.375 | 43.982 | 41.626 | 0.272 | 0.288 | 1.044 | 54.568 | 55.824 | 8 | 2.00 |
| 14 | 15.000 | 14.250 | 0.375 | 47.124 | 44.768 | 0.254 | 0.268 | 0.903 | 58.573 | 60.375 | 8 | 2.10 |
| 15 | 16.000 | 15.250 | 0.375 | 50.625 | 47.909 | 0.238 | 0.250 | 0.788 | 62.579 | 64.500 | 8 | 2.20 |

Example: Find the bursting point of 10-in. standard pipe 0.279 in. thick, internal diameter 10.192 in., tensile strength of metal, 50,000 lb.

$$\text{B. P.} = \frac{2 \times 0.279 \times 50{,}000}{10.192} = 2243 \text{ lb.}$$

### Wrought Iron Piping

Genuine wrought iron possesses many qualities which are desirable for a piping material. It is soft, and tough, is easily welded, and resists corrosion to a large degree. It has an ultimate tensile strength of about 45,000 lb. per square inch.

Wrought iron is made from pig iron by the "puddling" process. Puddling is so called because of the stirring or puddling of the molten metal by the workman. The impurities in the pig iron are in this way worked out and escape in the form of gases, while some is removed in form of slag. Balls of the plastic metal weighing about 200 lb. are formed by the puddler, and these are removed to the "squeezer" and "muck-rolls."

When the puddle-ball emerges from the squeezer it is known as a bloom, and after passing through the muck-rolls it is known as a muck bar, which is a rough bar about ¾ in. thick, 3 to 6 in. wide, and from 15 to 30 ft. long. This muck bar is sheared into short lengths from 2 to 3 ft. long, and stacked into small bundles which are placed in a reheating furnace, brought to a white welding heat, and then re-rolled into finished skelp. Skelp as previously explained are flat, thin strips of metal varying in thickness and width according to the exact size of pipe into which they are to be welded.

### How to Distinguish Iron from Steel

Few users of pipe are able to determine, from its appearance, whether it be iron or steel—in fact, many are certain that they are using iron pipe where a test will prove it to be steel.

Iron pipe is rough in appearance and the scale on it is heavy, whereas on steel the scale is light and has the appearance of small blisters or bubbles, underneath which the surface is smooth and somewhat white. When flattened, steel pipe seldom breaks; but if a fracture occurs, it will be noticed that the grain of the metal is extremely fine. Iron pipe when subjected to this test, readily breaks and shows a coarse fracture, due to the long fiber of this material.

The term wrought iron pipe is often used indiscriminately to designate all butt or lap welded pipe, whether made of wrought iron or steel. If requirements demand the use of either steel or iron, it should be distinctly stated in the specifications.

Dimensions and weights of standard grade pipe are furnished in Table I.

"Galvanized-iron" pipe is ordinary wrought pipe with a galvanizing coating. The grades are the same as those for wrought pipe, although the double extra heavy is seldom made. Galvanized pipe may be used for cold water on lines of comparatively small size, standard grade being sufficiently heavy for most purposes. When employed on blowoff lines, the extra-heavy grade is specified.

Wrought iron pipe is not carried in stock to any great extent, and if it is to be used in any considerable quantity, it should be ordered well in advance of the time it is required.

### Cast Iron

Because of its comparatively high corrosion-resisting qualities, it is advisable to use cast iron instead of

wrought iron for main steam pipes and branches where acids are used, or where the pipes must be placed underground or submerged. It is more durable than steel or wronght iron pipe, but its first cost is greater for the ordinary sizes required in a pressure line or in a distributing system. Due to its low elasticity and rather uncertain tensile strength, commercial cast-iron pipe is not suitable for lines subject to the strains of expansion, contraction and vibration, unless it is very heavy weight.

Cast-iron piping is not suitable for superheated steam service, or for temperatures above 575 deg. F. It is extensively employed for cold water on lines of comparatively large size, 4 in. and above, and is often used for hot water, in these sizes owing to the high cost of brass.

Cast-iron pipe should be made of a soft and tough quality of iron and should be subjected to a test pressure of at least twice the working pressure. The ultimate tensile strength may be taken as 20,000 lb. per square inch and the factor of safety at 12½.

Cast-iron pipe is made in a variety of thicknesses and weights, and manufacturers commonly tabulate the

TABLE II. STANDARD THICKNESSES AND WEIGHTS OF CAST-IRON PIPE

| Nominal Inside Diameter - In. | Class A 100 Ft. Head 43 Lb. Pressure | | | Class B 200 Ft. Head 86 Lb. Pressure | | | Class C 300 Ft. Head 130 Lb. Pressure | | | Class D 400 Ft. Head 173 Lb. Pressure | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Thickness Inches | Pounds per | | Thickness Inches | Pounds per | | Thickness Inches | Pounds per | | Thickness Inches | Pounds per | |
| | | Ft. | Length | | Ft. | Length | | Ft. | Length | | Ft. | Length |
| 3 | 0.39 | 14.5 | 175 | 0.43 | 16.2 | 194 | 0.45 | 17.1 | 205 | 0.48 | 18.0 | 216 |
| 4 | 0.42 | 20.0 | 240 | 0.45 | 21.7 | 260 | 0.48 | 23.3 | 280 | 0.52 | 25.0 | 300 |
| 6 | 0.44 | 30.8 | 370 | 0.48 | 33.3 | 400 | 0.51 | 35.8 | 430 | 0.55 | 38.3 | 460 |
| 8 | 0.46 | 42.9 | 515 | 0.51 | 47.5 | 570 | 0.56 | 52.1 | 625 | 0.60 | 55.8 | 670 |
| 10 | 0.50 | 57.1 | 685 | 0.57 | 63.8 | 765 | 0.62 | 70.8 | 850 | 0.68 | 76.7 | 920 |
| 12 | 0.54 | 72.5 | 870 | 0.62 | 82.1 | 985 | 0.68 | 91.7 | 1,100 | 0.75 | 100.0 | 1,200 |
| 14 | 0.57 | 89.6 | 1,075 | 0.66 | 102.5 | 1,230 | 0.74 | 116.7 | 1,400 | 0.82 | 129.2 | 1,550 |
| 16 | 0.60 | 108.3 | 1,300 | 0.70 | 125.0 | 1,500 | 0.80 | 143.8 | 1,725 | 0.89 | 158.3 | 1,900 |
| 18 | 0.64 | 129.2 | 1,550 | 0.75 | 150.0 | 1,800 | 0.87 | 175.0 | 2,100 | 0.96 | 191.7 | 2,300 |
| 20 | 0.67 | 150.0 | 1,800 | 0.80 | 175.0 | 2,100 | 0.92 | 200.2 | 2,500 | 1.03 | 229.2 | 2,750 |
| 24 | 0.76 | 204.2 | 2,450 | 0.89 | 233.3 | 2,800 | 1.04 | 279.2 | 3,350 | 1.16 | 306.7 | 3,680 |
| 30 | 0.88 | 291.7 | 3,500 | 1.03 | 333.3 | 4,000 | 1.20 | 400.0 | 4,800 | 1.37 | 450.0 | 5,400 |
| 36 | 0.99 | 391.7 | 4,700 | 1.15 | 454.2 | 5,450 | 1.36 | 545.8 | 6,550 | 1.58 | 625.0 | 7,500 |
| 42 | 1.10 | 512.5 | 6,150 | 1.28 | 591.7 | 7,100 | 1.54 | 716.7 | 8,600 | 1.78 | 825.0 | 9,900 |
| 48 | 1.26 | 668.7 | 8,000 | 1.42 | 760.0 | 9,000 | 1.71 | 908.3 | 10,900 | 1.96 | 1050.0 | 12,600 |
| 54 | 1.35 | 800.0 | 9,600 | 1.55 | 983.3 | 11,200 | 1.90 | 1141.7 | 13,700 | 2.23 | 1341.7 | 16,100 |
| 60 | 1.39 | 916.7 | 11,000 | 1.67 | 1104.2 | 13,250 | 2.00 | 1341.7 | 16,100 | 2.38 | 1583.3 | 19,000 |
| 72 | 1.62 | 1281.9 | 15,380 | 1.95 | 1547.3 | 18,570 | 2.39 | 1904.3 | 22,850 | ----- | ------ | - |
| 84 | 1.72 | 1635.8 | 19,630 | 2.22 | 2104.1 | 25,250 | ---- | ----- | ------ | ----- | ------ | - |

The above weights are for 12-ft. lengths including standard sockets.

grades for various pressures or heads. Thicknesses and weights for standard pipe up to 173 lb. pressure are furnished in Table II.

Thickness of cast-iron pipe is found by the following formula which was adopted by the American Water Works Association, and now used generally as the manufacturers' standard throughout the United States:

$$T = 0.25 + \frac{(P + P^1)\,r}{3300}$$

In which T = thickness in inches; P = maximum static pressure in pounds per square inch for which the pipe was designated; $P^1$ = allowance made for water ram, and r = radius in inches. This provides a large factor of safety to cover inequalities of the castings, strains placed on the pipe from other causes than water pressure, and to give sufficient thickness to insure the pipe against breakage in shipping and laying. For ordinary water-works conditions for pipes from 42 to 60 in. diameter, 70 lb. per square inch is enough for $P^1$, but for smaller pipe, Brackett allows the following values:

| Dia. of pipe in. = | 36 | 30 | 24 | 20 | 16 | 12 | 10 to 3 |
|---|---|---|---|---|---|---|---|
| $P^1$ lb. per sq. in. = | 75 | 80 | 85 | 90 | 100 | 110 | 120 |

## Brass Piping

Brass piping is generally employed for condenser tubes, feed water between pumps and boilers, and general hot water supply lines, on account of its resistance to corrosion and pitting, and its flexibility. It is extensively used for steam coils in water tanks or water coils in steam tanks for heating feed water for boilers, etc. Small sizes of brass pipe are employed for oil connections in machinery, as they can be easily bent, and when polished give a neat appearance.

For steam heating work brass pipe is made in all standard iron pipe sizes up to 6 in. in diameter. It has a thickness nearly equal to that of standard wrought iron pipe, and hence is of sufficient thickness to permit a similar thread. Standard lengths are 12 ft., and come without threads. Table III gives the sizes and weights of brass and copper pipe.

Thin brass tubing commonly employed for ornamental work, hand-rails, etc., is not of the proper size to take the standard pipe thread and is too thin for pressure work.

TABLE III. SIZES AND WEIGHTS OF IRON-PIPE SIZE OF BRASS AND COPPER TUBES

| Size of Tube Inches | Inside Diameter Inches | Outside Diameter Inches | Length Feet | Approximate Weight Per Foot | |
|---|---|---|---|---|---|
| | | | | Brass | Copper |
| 1/8 | 0.27 | 0.406 | 12 | 0.30 | 0.31 |
| 1/4 | 0.36 | 0.562 | 12 | 0.43 | 0.45 |
| 3/8 | 0.49 | 0.687 | 12 | 0.58 | 0.61 |
| 1/2 | 0.62 | 0.812 | 12 | 0.80 | 0.84 |
| 3/4 | 0.82 | 1.062 | 12 | 1.17 | 1.23 |
| 1 | 1.04 | 1.312 | 12 | 1.67 | 1.75 |
| 1-1/4 | 1.38 | 1.625 | 12 | 2.42 | 2.54 |
| 1-1/2 | 1.61 | 1.875 | 12 | 2.92 | 3.07 |
| 2 | 2.06 | 2.375 | 12 | 4.17 | 4.38 |
| 2-1/2 | 2.46 | 2.875 | 12 | 5.00 | 5.25 |
| 3 | 3.06 | 3.500 | 12 | 8.00 | 8.40 |
| 3-1/2 | 3.50 | 4.000 | 12 | 10.00 | 10.50 |
| 4 | 4.02 | 4.500 | 12 | 12.00 | 12.00 |
| 5 | 5.04 | 5.560 | 8 to 10 | 15.93 | 17.30 |
| 6 | 6.06 | 6.660 | 6 to 8 | 20.69 | 22.38 |

Brass castings average about 18,000 lb. per square inch ultimate tensile strength. For steam or valve metal, brass contains about 85 per cent copper, 7 per cent tin, 5 per cent zinc, and 3 per cent lead.

## Copper Piping

Copper pipe may be seamless drawn (up to 8 in. diameter) or may be brazed up from sheets. It is less used than formerly, since the ductility and flexibility of copper are found to be impaired by high temperature. At a temperature of 360 deg. F., its strength is reduced 15 per cent, and for this reason should never be used for high steam pressures and temperatures unless reinforced. The present high cost of copper makes its use prohibitive except in special service. It is employed in marine work on account of the sharp bends which are possible and its noncorrosive qualities.

Seamless copper pipe of iron pipe sizes may be employed for spring bends for main steam lines; sizes less than 4 in. may be bent cold. In steamship work, copper tubing which connects the boilers and the engines is generally made from sheet copper, with the seams dovetailed and then brazed, the ends of such tubes being provided with flanges brazed and riveted on; the sections are then bolted in position. As the heating of the copper sheet draws the copper lighter in some parts

than others, tubes made in this manner are not so well adapted for extremely high pressures as the seamless tubing.

Sheet copper possesses a tensile strength of about 35,000 lb. per square inch. Thickness of copper steam pipes may be determined from the formula:

$$t = 0.0001\ d \times p + 0.125$$

in which t = thickness in inches; d = internal diameter; p = pressure in pounds per square inch, and 0.125 is a constant.

Copper pipe sizes are similar to those for brass and are given in the foregoing table.

### Equation of Pipes

It is often desirable to know what number of pipes of a given size are equal in carrying capacity to one pipe of a larger size. At the same velocity of flow the volume delivered by the 2 pipes of different sizes is proportional to the squares of their diameters; thus, one 4-in. pipe will deliver the same volume as 4 2-in. pipes. With the same head, however, the velocity is less in the smaller pipe and the volume delivered varies approximately as the square root of the fifth power. Table IV has been calculated on this basis. Opposite the intersection of any 2 sizes is the number of the smaller-sized pipes required to equal one of the larger-sized pipes. Thus, one 5-in. pipe is equal to 9.9 or 10 2-in. pipes.

heat, is passed through a circular groove in the welding rolls with a supporting cast-iron ball or mandrel on the inside, as shown in Fig. 1, producing pressure upon the

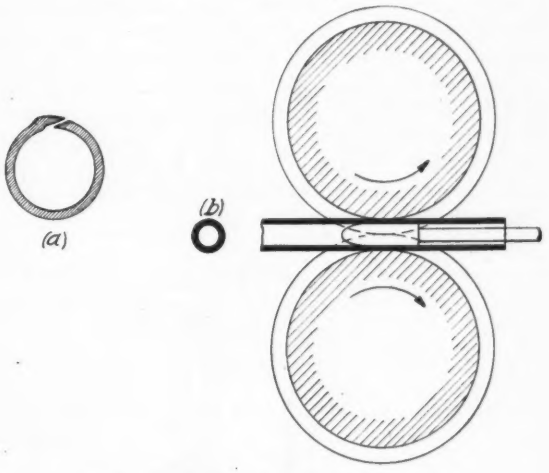



FIG. 1. ROLLERS FOR LAP WELDING PIPE

overlapped scarfed edges, welding them and reducing the thickness of the lap to the uniform gage of the rolled skelp.

TABLE IV. EQUATION OF PIPES

| Diameter Inches | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 14 | 16 | 18 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 5.7 | 1.0 | | | | | | | | | | | | | |
| 3 | 15.6 | 2.8 | 1.0 | | | | | | | | | | | | |
| 4 | 32.0 | 5.7 | 2.1 | 1.0 | | | | | | | | | | | |
| 5 | 55.9 | 9.9 | 3.6 | 1.7 | 1.0 | | | | | | | | | | |
| 6 | 88.2 | 15.6 | 5.7 | 2.8 | 1.6 | 1.0 | | | | | | | | | |
| 7 | 130.0 | 22.9 | 8.3 | 4.1 | 2.5 | 1.5 | 1.0 | | | | | | | | |
| 8 | 181.0 | 32.0 | 11.7 | 5.7 | 3.2 | 2.1 | 1.4 | 1.0 | | | | | | | |
| 9 | 243.0 | 43.0 | 15.6 | 7.6 | 4.3 | 2.8 | 1.9 | 1.3 | 1.0 | | | | | | |
| 10 | 316.0 | 55.9 | 20.3 | 9.9 | 5.7 | 3.6 | 2.4 | 1.7 | 1.3 | 1.0 | | | | | |
| 11 | 401.0 | 70.9 | 25.7 | 12.5 | 7.2 | 4.6 | 3.1 | 2.2 | 1.7 | 1.3 | | | | | |
| 12 | 499.0 | 88.2 | 32.0 | 15.6 | 8.9 | 5.7 | 3.8 | 2.8 | 2.1 | 1.6 | 1.0 | | | | |
| 13 | 609.0 | 108.0 | 39.1 | 19.0 | 10.9 | 7.1 | 4.7 | 3.4 | 2.5 | 1.9 | 1.2 | | | | |
| 14 | 733.0 | 130.0 | 47.0 | 22.9 | 13.1 | 8.3 | 5.7 | 4.1 | 3.0 | 2.3 | 1.5 | 1.0 | | | |
| 15 | 787.0 | 154.0 | 55.9 | 27.2 | 15.6 | 9.9 | 6.7 | 4.8 | 3.6 | 2.8 | 1.7 | 1.2 | | | |
| 16 | | 181.0 | 65.7 | 32.0 | 18.3 | 11.7 | 7.9 | 5.7 | 4.2 | 3.2 | 2.1 | 1.4 | 1.0 | | |
| 17 | | 211.0 | 76.4 | 37.2 | 21.3 | 13.5 | 9.2 | 6.6 | 4.9 | 3.8 | 2.4 | 1.6 | 1.2 | | |
| 18 | | 243.0 | 88.2 | 43.0 | 24.6 | 15.6 | 10.6 | 7.6 | 5.7 | 4.3 | 2.8 | 1.9 | 1.3 | 1.0 | |
| 19 | | 278.0 | 101.0 | 49.1 | 28.1 | 17.8 | 12.1 | 8.7 | 6.5 | 5.0 | 3.2 | 2.1 | 1.5 | 1.1 | |
| 20 | | 316.0 | 115.0 | 55.9 | 32.0 | 20.3 | 13.8 | 9.9 | 7.4 | 5.7 | 3.6 | 2.4 | 1.7 | 1.3 | 1.0 |

To find the number of pipes in a triangular pile, the following rule is offered: Add the one at the top to the number of pipes in the bottom row, and multiply by one-half the number in the bottom row. Thus, a triangular pile which contained 12 pipes in the bottom row would have $(12 + 1) \times 6 = 78$ pipes.

# Types of Piping

### Methods of Making Piping of Various Materials

Manufacture of pipe can be divided into 4 general classifications—welded, riveted, cast and seamless. Welded pipe may be divided into 2 sub-classes—lap and butt. Both are made from strips of rolled iron or steel, commercially called skelp. Butt welded pipe is commonly made in sizes from ⅛ to 3 in., lap welded pipe from 2 to 72 in.

### Lap Welded Pipe

In the case of the lap weld, the edges of the skelp are scarfed and it is bent in tubular form so as to lap one edge over the other; then when brought to a welding

Lap welded pipe is from 40 to 45 per cent more expensive than butt welded pipe, but due to the nature of the weld it will stand a greater internal pressure. The strength of a lap weld is approximately 92 per cent of that of the plate which it joins. Tests on commercial lap welded pipe have given an average bursting pressure

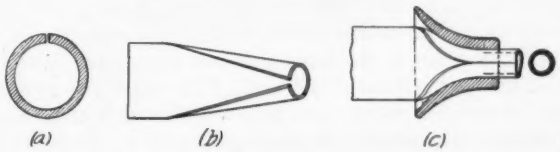



FIG. 2. SIMPLE METHOD OF BUTT WELDING PIPE

of 52,000 lb. per square inch for steel, and 31,000 lb. per square inch for wrought iron. Table I gives the weights and bursting pressures of large lap welded steel pipe.

The factor of safety for steam piping should not be less than 6.

Lap welded pipe is especially suited for high-pressure steam and water lines and vacuum service.

### Butt Welded Pipe

In the butt welded pipe, the square edges of the rolled strip are brought together by pressure when at a welding heat, and welded when the strip is drawn through a circular die, without the use of an interior support or mandrel. This method is shown in Fig. 2.

As a result of numerous tests, the strength of a butt weld has been found to be about 73 per cent of that of the plate which it joins. The average bursting pressure for butt-welded steel pipe is about 41,000 lb. per square inch, and that of butt-welded wrought iron is approximately 29,000 lb. per square inch.

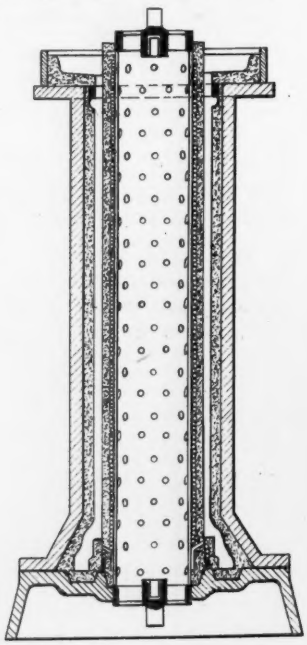


FIG. 3. VERTICAL MOLD FOR SOCKET PIPE

Butt welded pipe is less expensive than lap welded pipe, but due to its weaker joint is not suitable for steam or water under high pressure, or for pipes which must be bent. It is adaptable for gas service.

### Cast Pipe

In melting iron for castings, coke is the fuel most frequently employed, and alternate charges of coke and pig iron are placed in a cupola furnace which is fired with an air blast. The intense heat obtained results from the union of the carbon in the coke with the oxygen in the air of the blast. When the proper heat is obtained, a tap hole at the base of the cupola is opened and the molten metal flows into a ladle. It is then conveyed to the molds and poured.

A mold for a pipe casting is shown in Fig. 3. At the center of the mold is a rigid cylindrical core of specially prepared sand which is baked on a hollow core-bar and forms the opening in the pipe casting. In casting pipes, the core should be carefully placed in the mold so as to give equal thickness of metal all around the pipe; the core-bar should be as large as possible to prevent sagging in the middle.

Small pipes may be cast horizontally, but better at an angle of 45 deg. Large pipes should be cast vertically, as this makes a better casting, besides preventing the core from floating. When socket pipes are cast, the socket should be at the bottom of the mold, as shown in the illustration.

Rule for calculating the weight of cast-iron pipe is:

$$W = 2.45\ (D^2 - d^2)$$

In which W = weight per lineal foot; D = outside diameter in inches; d = inside diameter in inches; 2.45 = constant.

Brass, which is an alloy of copper and zinc, contains in some instances small amounts of lead or tin. Molds for brass differ slightly from those for iron for 3 reasons: Brass melts at a lower temperature; it does not run as fluid as iron; it has about double the shrinkage of iron in cooling.

All alloy metals burn if exposed to the air while melting, especially zinc and tin. In order, therefore, that the draft may be controlled and no free oxygen

FIG. 4. HOT-DRAWING BENCH WITH TUBE IN PROCESS

shall reach the metal, the ordinary brass furnace is a natural-draft furnace.

The metal does not come in direct contact as in the case of cast iron, but is contained in a fire-clay pot or crucible and bedded in the fire. In making brass, the copper is melted first, then the scrap brass, and next the zinc is added. Lead, if called for, is added just before pouring.

### Brazed Piping

Brazing is the process employed for joining copper surfaces, and is similar to soldering, except that brass is used to make the joint in place of the lead and zinc alloys which form solder. The metal that is melted in the joint is called spelter, and a suitable brass spelter for copper is made from equal parts of copper and zinc. This spelter melts at about 1400 deg. F. or 500 deg. below the melting point of the copper.

In order to remove the oxides produced under brazing heat, and to allow the brazing metal to flow freely, a flux is used, which frequently consists of calcined borax powder. The brazing metal is applied to the edges in a powder form and the work is rigidly supported on the brazing table and placed in such a position that the melted spelter will flow down and fill every part of the

joint surface. When brazing copper, the flame from the torches does not strike the metal directly, but glances from one side. Directing the flame against the work often melts the copper sheet before the operation is completed.

Although employed for steam service in marine work, copper pipe with brazed seams is rather unreliable, and a factor of safety from 10 to 15 is ordinarily allowed. In some systems, copper pipes over 8 in. in diameter are reinforced by wrapping them with 3/16-in. copper wire.

### Drawn Pipe

Referring to the manufacture of drawn steel pipe, we may divide it into 4 different processes:

First, the punching of solid billets by hydraulic power presses, and the subsequent rolling or hot-drawing of the hollow billet, reducing its wall thickness, and elongating it into the required pipe lengths.

Second, the plate-coupling process, which consists in taking a circular sheet or plate, and cupping it while hot in a series of operations until it has been formed into a shallow cup of approximately the required diameter; then elongating the shallow cup by a succession of hot-drawing operations on a solid mandrel through a succession of dies, thereby reducing its wall to the desired thickness. A hot-drawing bench is shown in Fig. 4. This process is ordinarily used on pipes of large diameter.

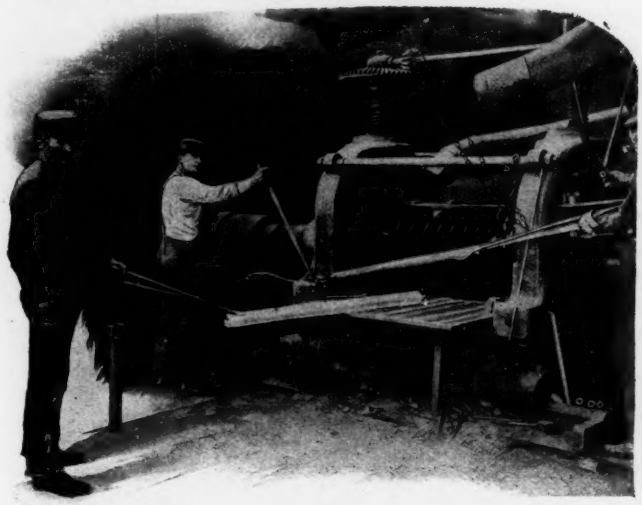


FIG. 5. ROLLING TUBES AFTER PIERCING OPERATION

Third, the cast-hollow-billet process, where a cast-steel, hollow, tubular blank is used as a basis of manufacture, which is elongated and reduced in wall thickness by rolling over a plug or mandrel, or by hot-drawing operations as previously described.

Fourth, the piercing process, which starts with a round solid billet, which is passed through angularly disposed rolls, giving a high rotating speed and a slow advancing movement to the billet, forcing it over a pointed mandrel, increasing its length and changing it from a solid to a tubular form. This is by far the most important of the seamless processes, and although it is a comparatively new development, it has made great progress. Figure 5 shows one of the rolling operations in this piercing method, which is commonly called the "Mannesmann Process," named after its inventor, a German engineer.

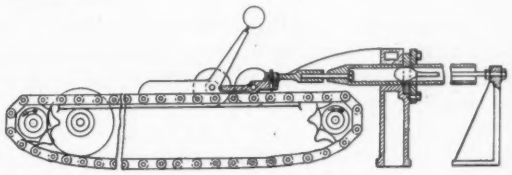


FIG. 6. CHAIN-DRIVEN DRAW BENCH FOR COLD DRAWING

Seamless piping is well adapted for boiler tubes, coils, cylinders, piston rods, and exhaust lines.

Boiler tubes were formerly made of charcoal iron, but due to improved process of manufacture, the solid-drawn seamless steel boiler tubes are now common, possessing the same degree of ductility with a great tensile strength.

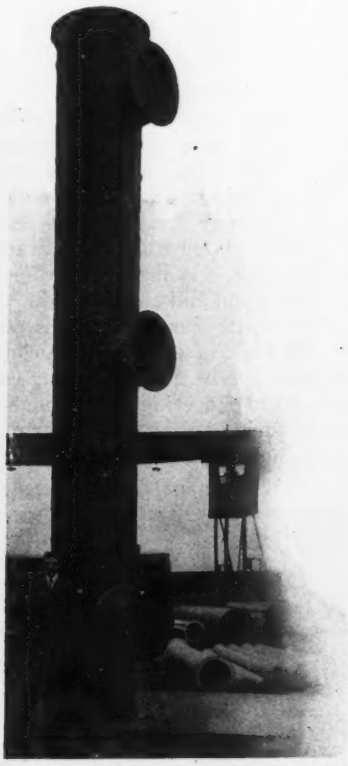


FIG. 7. EXHAUST STEAM HEADER OF SPIRAL RIVETED PIPE

Solid-drawn copper and brass tubes are made by the cold-drawing process. In some instances, the edges of the metal are dovetailed and brazed, making what is known as a "cramped joint." The tube is then fixed on a solid steel mandrel with the edges at one end of the tube turned over the shoulder of the mandrel, and both are drawn repeatedly through draw plates of smaller size, until the required external diameter is obtained, the internal diameter remaining the same as that of the mandrel.

In common practice, solid cold-drawn steel, brass or copper tubes are produced by what is known as the

"short mandrel" system. Here the piece from which the tube is drawn is turned and bored out of solid bar of the desired quality and "cold-drawn" as explained above, but *over* a mandrel, which is stationary, being supported on the end of a rod of greater length than that of the tube. A chain-driven draw-bench for cold-drawing is shown in Fig. 6. It is necessary to anneal the tube frequently during the drawing process to restore the ductility of the metal.

TABLE I. WEIGHTS AND BURSTING PRESSURES OF LARGE LAP WELDED STEEL PIPE

| Inside Diameter Inches | Thickness Inches | Weight Per Foot Pounds | Approx. Bursting Pressure Lb. Per Sq. In. |
|---|---|---|---|
| 12 | 0.187 | 25.8 | 1562 |
| 14 | 0.187 | 30.1 | 1339 |
| 16 | 0.187 | 34.2 | 1172 |
| 18 | 0.187 | 38.4 | 1041 |
| 20 | 0.187 | 42.6 | 937 |
| 22 | 0.187 | 46.8 | 852 |
| 24 | 0.187 | 51.0 | 781 |
| 30 | 0.187 | 64.0 | 625 |
| 36 | 0.250 | 103.0 | 694 |
| 40 | 0.312 | 142.0 | 781 |
| 42 | 0.375 | 179.0 | 893 |
| 48 | 0.375 | 204.0 | 781 |
| 54 | 0.500 | 306.0 | 926 |
| 60 | 0.625 | 426.0 | 1040 |
| 66 | 0.750 | 563.0 | 1132 |
| 72 | 1.000 | 822.0 | 1386 |

## Riveted Piping

Straight riveted pipe and spiral riveted pipe are furnished in lengths up to 40 ft. with pressed or forged-steel flanges riveted to the ends. It is employed extensively in noncondensing power plant work for exhaust-steam mains, condenser service, large drains, etc., but should never be used for steam, feed water, or similar high-pressure work. It is also suitable for water supply lines, brine circulation and suction lines. Spiral riveted pipe, because of its construction, is stronger than straight riveted pipe of equal size, thickness and quality. The single seam in this pipe, being continuous and helical from end to end, stiffens it throughout its length.

In manufacturing spiral pipe, a strip of sheet steel it wound into helical shape with one edge overlapping the other for riveting the seam. In some processes the sheet is rolled and formed with the outer lap slightly offset so as to give a metal to metal contact and a smooth interior. Due to mechanical construction, the seam is the strongest part of the pipe, which is demonstrated by hydraulic tests for bursting pressure. It is usually made in different gages up to ¼ in. thickness, and furnished in any length desired up to 40 ft. for asphalt-coated pipe, and 20 ft. for galvanized pipe. Data on spiral riveted pipe is given in Table II.

For exhaust steam, suction, condenser work, compressed air, etc., the galvanized pipe is preferable, the asphalt-covered pipe is recommended for water supply lines, dredging work, hydro-electric service, etc.

TABLE II. DATA ON SPIRAL RIVETED PIPE UP TO 12-IN. DIAMETER
(Plain Ends)

| Inside Diameter Inches | Thickness U.S. Standard Gauge | Approximate Price Per Foot: Asphalt Coated | Approximate Price Per Foot: Galvanized | Approximate Weight in Lb. Per Ft. Asphalted | Approximate Bursting Strength Lb. Per Sq. In. |
|---|---|---|---|---|---|
| 3 | 20 * | $ .35 | $ .47 | 1.9 | 1500 |
| | 18 ** | .39 | .53 | 2.3 | 2000 |
| 4 | 20 | .46 | .61 | 2.4 | 1125 |
| | 18 * | .505 | .68 | 3.0 | 1500 |
| | 16 ** | .52 | .73 | 3.7 | 1875 |
| 5 | 20 | .55 | .74 | 2.9 | 900 |
| | 18 * | .61 | .82 | 3.7 | 1200 |
| | 16 ** | .63 | .88 | 4.5 | 1500 |
| 6 | 18 | .72 | .97 | 4.3 | 1000 |
| | 16 * | .74 | 1.04 | 5.3 | 1250 |
| | 14 ** | .87 | 1.21 | 6.6 | 1560 |
| 8 | 18 | .97 | 1.31 | 5.8 | 750 |
| | 16 * | .99 | 1.40 | 7.1 | 935 |
| | 14 ** | 1.16 | 1.62 | 8.8 | 1170 |
| 10 | 16 * | 1.24 | 1.73 | 8.8 | 750 |
| | 14 ** | 1.45 | 2.01 | 11.0 | 935 |
| | 12 *** | 1.91 | 2.69 | 15.3 | 1310 |
| 12 | 16 * | 1.48 | 2.07 | 10.6 | 625 |
| | 14 ** | 1.72 | 2.40 | 13.0 | 780 |
| | 12 *** | 2.27 | 3.19 | 18.2 | 1080 |

* Denotes standard thickness for Spiral riveted pipe.
** Denotes extra heavy.
*** Denotes double extra heavy.

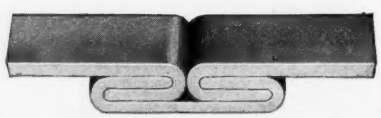


FIG. 9. REINFORCED JOINT FOR SPIRAL PIPE

In the making of Standard reinforced spiral pipe, which is neither welded or riveted, 2 strips of steel of different widths are employed, which are rolled to shape on the edges. They are then interlocked, as shown in Fig. 9, and rolled down under high pressure. This arrangement provides 4 thicknesses of metal at the point where the reinforcing band passes around the pipe in the form of a continuous seam. A soft open hearth steel is used, which will stand the required bending, and ample folds are provided on both strips so that a large bearing surface is obtained at the seam. Because of its strength, this style of pipe has been successfully applied to smoke stack service.

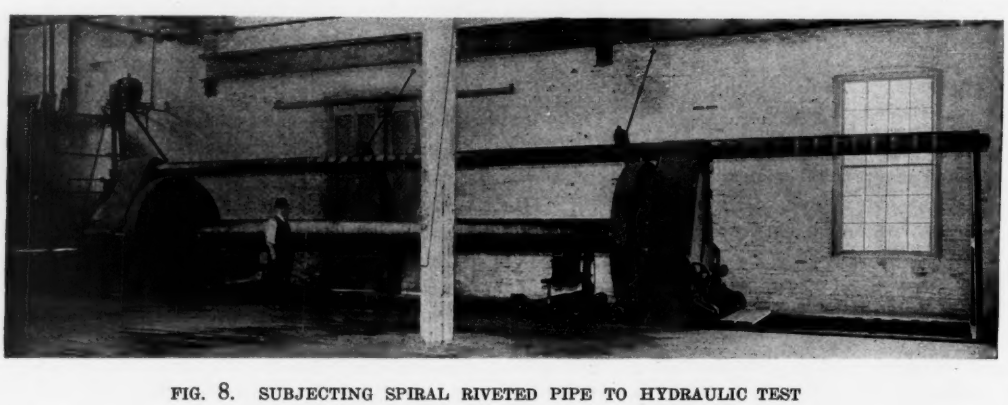


FIG. 8. SUBJECTING SPIRAL RIVETED PIPE TO HYDRAULIC TEST

# Pipe Joints

DETAILS OF VARIOUS METHODS OF JOINING PIPES IN A STRAIGHT LINE

PIPE fitting is largely a matter of securing tight joints, and great care and good judgment are required if best results are to be had, particularly where high pressures are used. In ordinary power plant piping, 2 types of pipe joints are commonly employed; these are screwed and flanged joints. Where cast-iron pipes, such as water mains, are used, the common joints are flanges cast on or the bell and spigot type.

Screwed joints are the most common in small piping and are frequently used in sizes as large as 8 and 10 in., although in the larger sizes screwed joints are difficult to work with and many engineers recommend flanged joints in all piping above 2½ and 3 in.

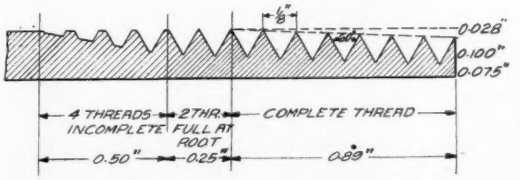



FIG. 1. TAPERED THREAD FOR 2½-IN. PIPES

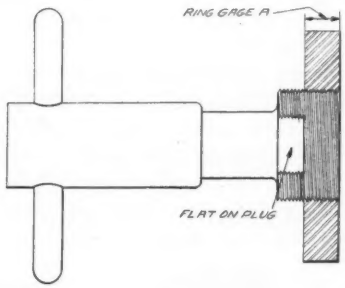
Pipe threads have 2 duties to perform, one to hold the pipe ends together, the other to prevent leaks. The standard machine thread would perform the first duty, but in drawing the pipe ends together a slight opening is left on one side of the thread through which steam can leak. To overcome this difficulty the tapered thread was devised, a section of which is shown in the sketch herewith. With a tapered thread on the fitting to match that on the pipe end, a tight joint throughout the entire length of the thread is ensured when the fitting is screwed up tight on the pipe end. In the table on pipe dimensions, page 3, the length of perfect screw is given, being represented by the space marked "complete thread" in the sketch. The standard taper is 1 in 32 to the axis of the tube.

FIG. 2. SEVERAL TYPES OF NIPPLES

In pipe lines of considerable length, made up of screwed joints, it is desirable to make some provision for opening the line at one or more joints, otherwise the entire line may have to be taken down to make some slight repair near the beginning of the run.

Pipe nipples are short pieces of pipe threaded at both ends, and are convenient in making up connections with screwed joints. They are made for all sizes of pipe and any convenient length, and threaded right-handed, left-handed or right-and-left handed, tapered or straight. The right-handed nipple is used in cases where it is possible to extend the pipe by turning a fitting and the right-and-left where the fitting cannot be turned to extend the pipe. To secure a tight joint against high pressure, the tapered thread is almost a necessity and should be used wherever possible; where a long thread is necessary, however, the straight thread must be used.

AMERICAN BRIGGS STANDARD FOR THICKNESS OF SCREWED FLANGE




| Pipe Size | Adopted Thickness of Ring Gage A | Pipe Size | Adopted Thickness of Ring Gage A |
|---|---|---|---|
| 1/8 | 0.1801 | 5 | 0.937 |
| 1/4 | 0.200 | 6 | 0.958 |
| 3/8 | 0.240 | 7 | 1.000 |
| 1/2 | 0.320 | 8 | 1.063 |
| 3/4 | 0.339 | 9 | 1.130 |
| 1 | 0.400 | 10 | 1.210 |
| 1-1/4 | 0.420 | 12 | 1.360 |
| 1-1/2 | 0.420 | 14 | 1.562 |
| 2 | 0.436 | 15 | 1.687 |
| 2-1/2 | 0.682 | 16 | 1.812 |
| 3 | 0.766 | 18 | 2.000 |
| 3-1/2 | 0.821 | 20 | 2.125 |
| 4 | 0.844 | 22 | 2.250 |
| 4-1/2 | 0.875 | 24 | 2.375 |

Close nipples may be made by threading the end of a pipe and cutting the threaded part off the desired length. This gives a straight thread the entire length. The close-shouldered nipple is threaded from both ends with a tapered thread, the threads coming close together at the center. Short and long nipples are alike, except for length, the thread at each end being just the length to enter the fittings. Nipples should be of extra heavy pipe as they are turned with a wrench and are easily distorted in shape. Some stock nipples used for radiator connections are made with a hexagonal nut at the center, have right and left threads, and are turned with a thin wrench called a spanner.

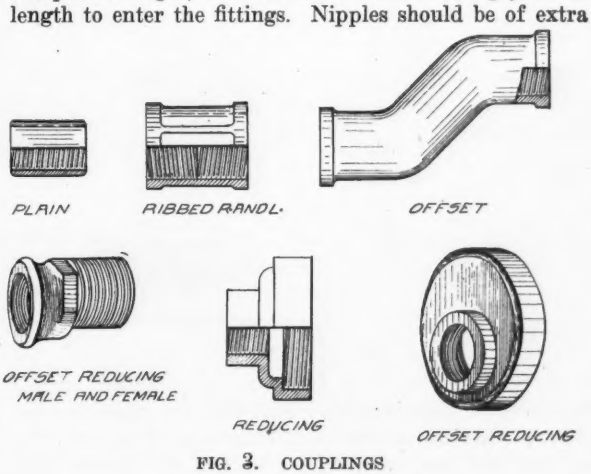



FIG. 3. COUPLINGS

Locknut nipples or long screws are convenient in making up final connections when a union is not at hand. This consists of a short nipple with a tapered thread at one end and a long thread at the other. A

locknut made by cutting off the end of a coupling and reaming it to give a small recess for packing and a straight-thread coupling, reamed in a similar manner, are screwed onto the long thread of the nipple. With the pipe in place the coupling is screwed off the nipple onto the end of the pipe to half the length of the coupling, or until tight, and the locknut is then screwed tight against the coupling with packing made of lamp wick or hemp soaked in white lead in the reamed space between coupling and locknut.

For connecting continuous lengths of pipe, the coupling is used. This is really a sleeve with tapered thread inside. When a long thread nipple or pipe is used the coupling has straight threads, the coupling being used with a locknut as described above for a final connection. Right-and-left couplings are sometimes used for final connection when the pipes cannot be turned.

FIG. 4. BUSHINGS

When connecting pipes of different sizes, the reducing coupling is employed. This is a casting similar to the coupling, except that one opening is reduced in size. Offset or eccentric reducing couplings, with openings not concentric, are employed where it is desired to keep one side of the pipe run in a straight line as along a floor, wall or ceiling. The offset male and female reducing coupling is used to connect a fitting to a pipe of larger size and is convenient in connecting up steam radiators. The plain offset resembles a bent coupling and is used to continue a run at an offset but parallel line.

For connecting a pipe to an outlet of larger size, the "bushing" is used similar to a coupling but threaded inside and out with taper threads, usually right-hand.

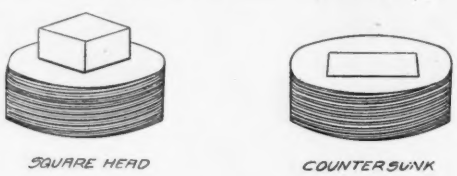



FIG. 5. PLUGS

The faced or flush bushing is threaded the entire length of its surface and enters the fitting opening completely; another type has an hexagonal portion for convenience in turning it with a wrench. Bushings are also sometimes made eccentric for convenience in connecting up piping.

Plugs are used to close tapped openings in fittings where pipe connections are not required. These are usually made with a square head and right-hand tapered thread, but the faced type is sometimes used to enter the fitting flush to the opening and with a square depression in the face by means of which it can be turned.

For dead-ending a pipe, a cap is used which is a hollow casting threaded inside. It may have a square projection, hexagonal or ribbed body or be entirely plain, but is always threaded tapered, either right or left hand.

## Unions

For making final connections the pipe union is the most convenient fitting. It consists essentially of 3 parts, 2 sleeves threaded to screw onto the ends of the pipes to be joined, and a threaded ring to draw the sleeves together and make a leak-proof joint. In the standard type as recommended by the American Society of Mechanical Engineers, a gasket is used to secure a good seating surface, but in high pressure steam and

FIG. 6. CAPS

water piping the ground joint is preferable; the seat being made of non-corrosive metal and with seating surfaces of the ball and socket shape, absolute alinement of the pipes is not necessary.

Unions are made up with any combination of threads desired, and combination unions with ells, tees and crosses are also available. An example of a brass-to-iron ground ball and socket joint with an inserted brass ring is the Railroad union made by Crane Co. The brass seat is firmly forced into place under heavy pressure and both ends of the union are ground together, forming a perfectly tight and non-corrosive seat for steam, water, air, gas or oil, under pressures up to 200 lb. per square inch.

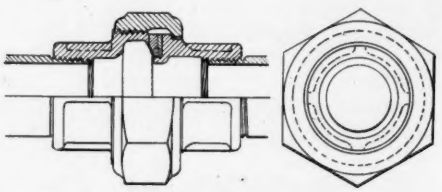


FIG. 7. PART SECTIONAL VIEW OF STANDARD PIPE UNION

The Walco union made by the Walworth Mfg. Co. is of the inserted ring type, the form of the ring taking the shape of a dove-tail joint. In the illustration shown here the ends of the union are made octagonal, as is also the ring for convenience in connecting up with a wrench.

In the Dart union a bronze-to-bronze seat is employed which is of the ground ball and socket type, thus doing away with a gasket and taking care of slight irregularity in alinement.

Unions made by the Jefferson Union Co. have a brass ring pressed into the seat at one end, away from the runway of the fitting. The seat is a ground ball and socket joint and the union requires no packing. The threads in the end of the union are tapered, making a perfect fit with the tapered pipe threads.

Two special types of Jefferson unions are shown. These are known as the union elbow and union tee. The seats of these are similar in all respects to that of the regular Jefferson union. In connecting piping slightly out of alinement, the Jefferson flange union is convenient. This has the brass to iron joint, making a gasket unnecessary, and is made in 3 parts. These fit together in ball joints, which make up tight when the pipes are slightly out of line. The flange union is suitable for pressures up to 200 lb.

Kewanee Unions, made by the National Tube Co., are made in 3 pieces without an inserted ring. One end of the union, however, is of brass, giving an iron-to-brass seat and an iron-to-brass thread, thus eliminating corrosion at these 2 important points. The seat is ground so that the union does not require packing.

throughout except the brass seat ring. This is done after the threading so that the threads are protected perfectly.

Rockwood unions are made of pressed steel with ground bronze seats, the joint being of the ball and socket type. The material used expands and contracts the same as pipe metal, so that leakage from unequal expansion is eliminated in this union, and corrosion is prevented by sherardizing.

An all brass union made by the Lunkenheimer Co. is shown in cross-section herewith, having the ground seat, ball and socket feature, which eliminates the necessity of using packing.

Standard brass unions are made by the Wm. Powell Co., with hexagonal sides on both ends and the ring which greatly facilitate their connection. Another style of all brass union with ground joints is made by the

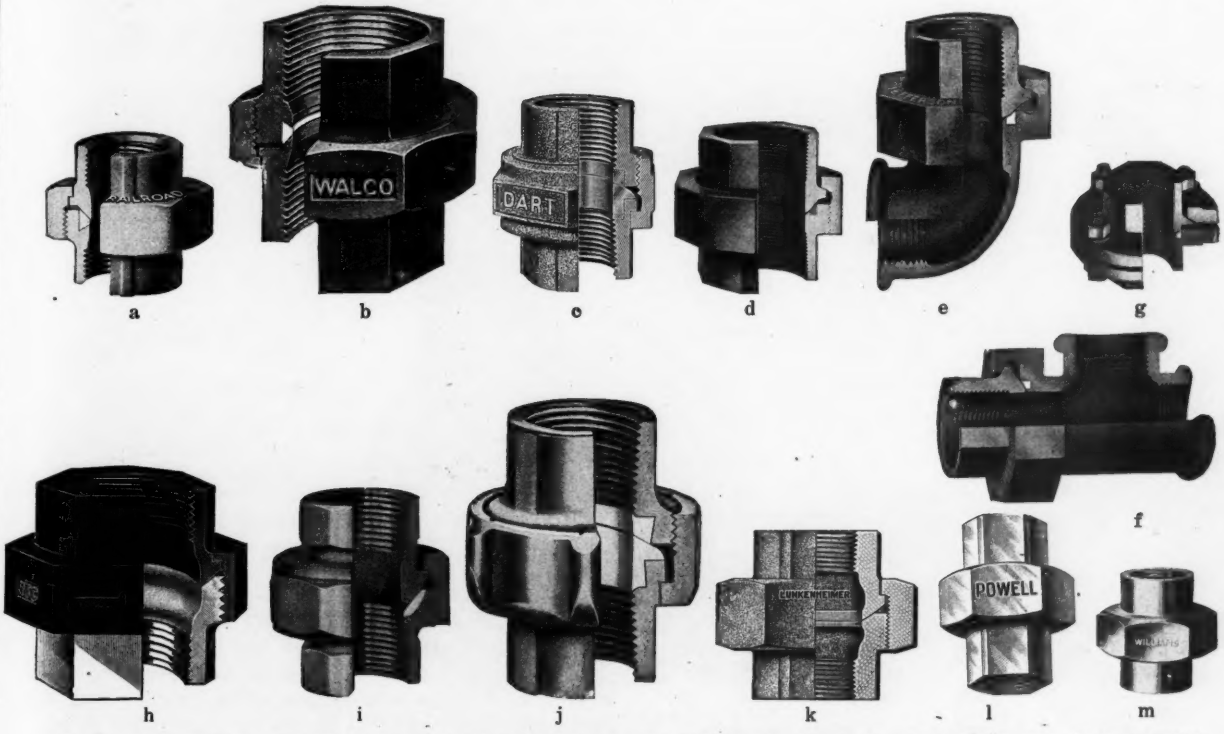



FIG. 8. COMMERCIAL UNIONS: A, CRANE CO. RAILROAD; B, WALWORTH CO.; C, E. M. DART M'F'G. CO.; D, JEFFERSON UNION CO.; E, JEFFERSON UNION ELL; F, JEFFERSON UNION TEE; G, JEFFERSON FLANGE UNION; H, NATIONAL TUBE CO., KEWANEE; I, MARK; J, ROCKWOOD SPRINKLER CO.; K, LUNKENHEIMER, BRASS; L, POWELL, BRASS; M, WILLIAMS, POLISHED BRASS

Cold drawn steel is used in making the 3 principal parts of the Mark Union, manufactured by the Mark Manufacturing Co. These pieces are formed by a series of cold drawing and forging operations from rolled steel, the advantage of this material for piping purposes being that contraction and expansion due to heat conform to that of the piping employed. One end has its seat formed by densifying the metal under high pressure, giving a hard, uniform and smooth seat. The other end is formed with a suitable receptacle for a drawn brass seat ring, giving a hard steel seat against a soft brass seat ring and the surfaces ground together makes a perfectly tight joint against high pressures without the use of packing. To protect the union against corrosion it is sherardized

D. T. Williams Co., and has both ends plain and the ring hexagonal; this particular union is polished all over and makes a neat appearance.

### Flanged Joints

For the larger sizes of piping and higher pressures, flanged joints are almost universally employed. The advantages are that the pipes do not have to be turned, any individual length may be removed without disconnecting the rest of the line, individual joints are more easily repaired, and a tighter connection can be made. Flanged joints are, however, more expensive and accurate alinement is necessary, except where special provision is made.

Standard pipe flanges are cast rings which fit over the ends of the pipe. When of the screwed type, the flange is tapped and screwed on to the end of the pipe a sufficient distance to secure proper strength.

The American Briggs standard recommended by the American Society of Mechanical Engineers is noted in the accompanying table. In some cases a boss is cast on the flange, making possible the use of a longer thread.

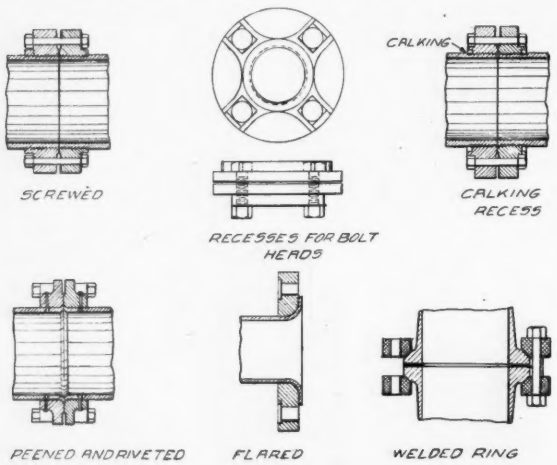



FIG. 9. FLANGE JOINTS

One side of the flange is faced to fit accurately the flange of the joining pipe. Holes are drilled for bolts to hold the companion flanges together, standard practice using 4 or multiples of 4 bolt holes in the flanges. Some flanges have recesses into which the heads of the bolts fit to prevent them from turning. Another provision sometimes made is a calking recess to be filled with lead as an extra precaution against leaks.

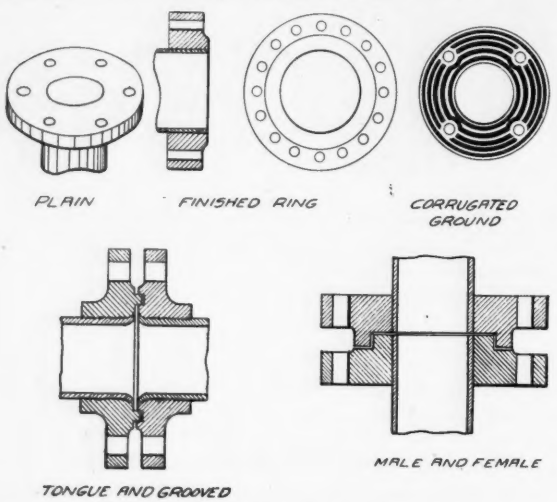
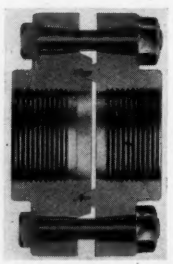



FIG. 10. FLANGE FACES

Flanges are sometimes shrunk, peened and riveted to the pipe. The method employed is to turn the end of the pipe smooth for the length of the flange, bore the hole in the flange slightly smaller than the outside diameter of the pipe, heat the flange, insert the pipe and allow it to cool. The inside end of the flange bore is chamfered, the end of the pipe is peened out into this chamfer and rivets are put through the pipe and flange, making the joint doubly secure.

Flanges are sometimes held on the pipe by flaring the end of the pipe after the ring has been slipped on. In this case the ring fits loosely around the pipe, forming what is called the Van Stone joint. The end of the pipe is flared out and faced up true to give a surface against which the next pipe end fits. The flanges in this case merely hold the ends of the pipe together. As the pipe end is flared it becomes thin and the flange is sloped slightly to give even contact or the pipe is upset before being flared in order to prevent the thinning out.

A modified form of the flared joint is the welded ring type in which a ring is welded to the end of the pipe. The loose flange fits a 45-deg. seat on the back of the ring and with its companion holds the pipe ends together. This type of joint allows the pipe to be turned and is particularly convenient in connecting up bent pipes.



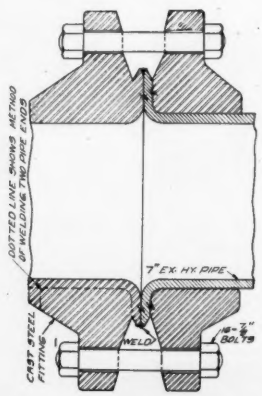



FIG. 10A. THE EDWARD DOUBLE TIGHT JOINT

FIG. 12. SECTION OF EDWARD WELDED JOINT

Various forms of flange faces are used, the most common being the plain face which has the entire side of the flange smoothed free of irregularities. Another common form of flange is faced around the opening a short distance, but the rest of the surface is turned down, giving a recess between the outer edges of the flanges when the joint is made up. A modification of this is a flange with a corrugated face, as illustrated herewith, the ground face consisting of several concentric rings of metal projecting from the body of the flange.

The tongue and groove and the male and female types of flanges are extensively used for high pressure piping as these forms prevent the blowing out of gaskets. Ground joints are no different from those described above except that greater care is taken to give an exact fit between flange faces, the surfaces being accurately ground to fit so as to need no gaskets.

The Edward double-tight joint is a pipe joint applicable to flange unions, pipe couplings and fittings. One side of the joint consists of a "V" shaped annular groove, the other portion consists of a "V" shaped annular projection which is made to fit the annular groove. The projecting element, however, is made at a slightly sharper angle than the groove insuring line

contact at the points. This projecting element is relieved by an annular slot which permits a certain amount of spring or resiliency when the 2 portions are clamped together. A detail of this joint is illustrated in Fig. 10A. This joint is especially applicable to steam lines where there is a great deal of contraction and expansion, the design of the joint being such that it compensates for this expansion, contraction and whatever vibration there may be in the line.

While the cost of this joint has somewhat hindered its use for ordinary steam lines, it has not affected its use for high-pressure steam lines and for hydraulic and ammonia service where an absolutely tight joint is essential. The patent rights for the double tight joint are controlled by the Edward Valve & Manufacturing Co.

Flange faces that are not ground are fitted together with gaskets made of material suitable to the pressure, temperature and fluid handled. Soft gaskets are made of fibrous and composition materials and can be purchased already cut for common pipe work, but are often cut from sheet packing carried in stock, except when doing a big piping job. It is common with plain-faced flanges to cut the gasket full size of the flange with holes for the bolts as well as for the pipe openings. This is not necessary, however, as the gasket may be cut with a smaller diameter, allowing it to be inserted within the bolt circle, which form is also easier to install.

Gaskets must have sufficient strength to withstand the pressure under which they work and this limits the use of soft gaskets to moderate and low pressures, although soft gaskets reinforced with wire cloth may be used where pressures are comparatively high. Where the face of the flange is of the tongue and grooved type soft gaskets may be used to advantage on high pressures as they cannot be blown out of the joint. Several forms of copper gaskets filled with asbestos or other fibrous material to give them the elasticity necessary for filling up the small irregularities of a flange face are on the market and give good satisfaction in all kinds of high pressure piping; illustrations are shown here of types made by the McCord Mfg. Co. and the Victor Mfg. & Gasket Co. All copper corrugated gaskets, also those having corrugations filled with asbestos are patented articles made by the Goetze Gasket & Packing Co., and procurable in standard sizes on the market. Corrugated gaskets made by the Smooth-on Mfg. Co. are of specially prepared metal which expands and contracts with the pipe and is coated with Smooth-on cement, which sets the joints. Even a plain soft copper wire in the shape of a ring also makes a serviceable metallic gasket. One

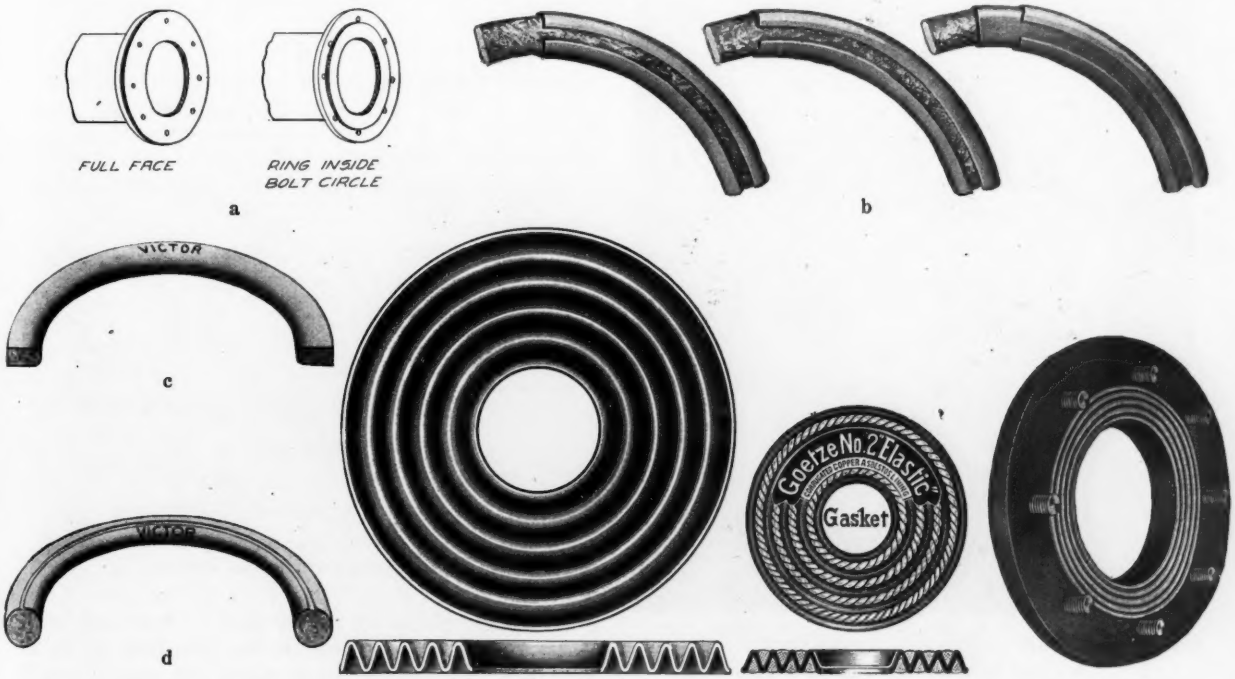



FIG. 11. TYPES OF GASKETS. A, FORMS OF FIBROUS GASKETS; B, MC KIM GASKETS OF MC CORD MFG. CO., SINGLE COPPER RUBBER FILLED, SINGLE COPPER ASBESTOS FILLED, DOUBLE COPPER ASBESTOS FILLED; C, FRENCH TYPE VICTOR; D, ROUND TYPE VICTOR; E, GOETZE, ALL COPPER CORRUGATED; F, GOETZE ASBESTOS FILLED CORRUGATED; G, SMOOTH-ON NARROW WIDTH

of the principal advantages of metallic gaskets is the fact that they can be used over and over again. In some cases no flanges are used, the ends of the pipe being welded solidly together; this makes a solid pipe line and for permanency is unexcelled.

The Edward welded joint here illustrated is an advancement in pipe coupling which removes the trouble attended upon the gasket joint. The line drawing Fig. 12 shows a clear detail of how this joint is made. It is applicable to joints between fittings or between pipe and fitting, or a flange union. In this joint the companion flanges, or a flange of a fitting, must be especially prepared as outlined. Companion flanges fit loosely on the pipe, and as shown, the end of the pipe is flared and rolled back, the outer edge of which is

suitably machined for welding and the face machined true. The welding takes place in the small "V" shaped opening between the 2 tips of the pipe or of the pipe and the fitting. The general dimensions and the bolting of the flanges for this joint are a great deal heavier than called for by the accepted standards for extra heavy fittings.

Photograph Fig. 12A is a close-up view of a portion of a steel header. The joint on the header proper is 17 in., while the 2 joints shown on either side of the valve in the boiler lead are 7 in. The patent rights for this joint are controlled by the Edward Valve & Manufacturing Co.

### Joints for Cast-Iron Pipe

While the small sizes of cast-iron pipe are put together with screwed joints, the sizes ordinarily used for conveying water have flange joints with the flanges cast

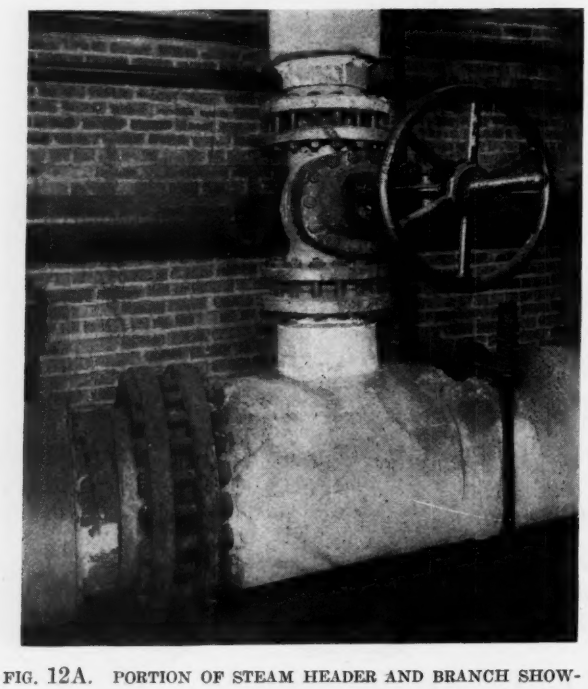


FIG. 12A. PORTION OF STEAM HEADER AND BRANCH SHOWING USE OF EDWARD WELDED JOINT

on the end of the pipe, the type illustrated as Universal in Fig. 13 being most commonly used. The flanges are turned to a finish and the bolt holes drilled at the factory or shop before delivery to the job.

Flanged piping requires very careful alinement and for underground lines such careful work is next to impossible so the bell and spigot joint is most commonly used for this work. All cast-iron bell and spigot type joints are of the same form and shape in regard to the bell and bead of the spigot regardless of size; that is, the lead space and oakum space are the same, whether the pipe is 4 in. or 30 in. in diameter. The sketch shows these dimensions.

When putting in the oakum, drive it hard and even with a yarning tool up to the joint of the taper in the bell, keeping the pipe centered so as to obtain an even lead space all around. After the oakum is driven the pouring band is put on and holes stopped up with mud. The lead is heated until it will char a pine stick, then poured. The lead is then driven up, the procedure being first to drive up and cut off the pouring gate, then with a small tool, beginning at the bottom, drive the lead hard, finishing with a tool that just fills the lead space.

For pipe lines in uneven ground and at the bottom of streams, a flexible joint is necessary. Two types of flexible joints for cast-iron pipe are illustrated in Fig. 13; these give the proper flexibility, yet when properly made up will hold against common pressures.

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Because of its fire-resisting qualities, asbestos rope has been suggested for use in life lines and fire-escape ladders, and to secure information as to its availability tests were made in the laboratory of the Tomsk Institute of Technology, the conclusions from which are stated in Engineering of London.

Wetting produced loss of tensile strength from 4 to 12 per cent. When heated and cooled, the loss of

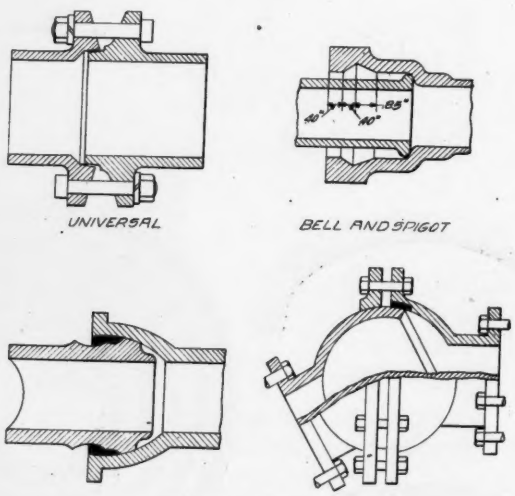



FIG. 13. CAST-IRON PIPE JOINTS

strength was slight up to 250 deg. C. (480 deg. F.); but if wetted after cooling, the loss was from 25 to 35 per cent. For temperatures above 300 deg. C. (570 deg. F.), however, the loss in strength was rapid, being 25 to 28 per cent at 360 deg. C. (682 deg. F.) and 25 to 37 per cent at 500 deg. C. (932 deg. F), and the after wetting had effect also, increasing the loss to 40 per cent at 360 deg. C. and 44 per cent at 500 deg. C. This effect was due to burning out of organic matter in the rope as indicated by the smell.

Heating to still higher temperatures and cooling but not wetting showed losses of 37 to 60 per cent at 600 deg. C. (1112 deg. F.), 71 to 87 per cent at 710 deg. C. (1310 deg. F.) and 89 to 100 per cent at 750 deg. C. (1382 deg. F.). Heated under load, the strands broke at 540 to 650 deg. C. (1004 to 1202 deg. F.) under a load of about half the original tensile strength.

Results warrant the conclusion that rope of asbestos fibre is not suitable for fire purposes and as a heat insulator for manila or steel ropes the asbestos becomes brittle at 600 deg. C. (1112 deg. F.) hence would be of little value.

# Pipe Branches and Turns

## Devices for Connecting Pipes at Angles

THE general term applied to the devices for putting lengths of pipe together is pipe fittings. These may be either screwed or flanged, depending upon the size of pipe and pressure maintained in it. Among the screwed fittings we have ells, tees, y's, crosses and special fittings. The term "ells" is the tradesman's contraction of the word elbows, which are fittings used to

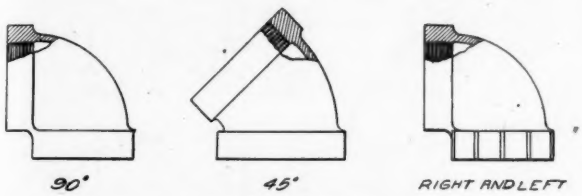



FIG. 1. ELBOWS

change the direction of pipe run, the standard ells having openings at 90 and 45 deg. from the straight run. These are threaded right-handed, or may be secured right-and-left, the latter being used where the fittings cannot be turned on the end of the pipe. The openings for connecting onto the pipe are reinforced over the

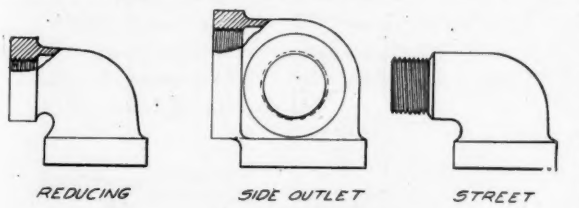



FIG. 2. SPECIAL FORMS OF ELBOWS

threads to insure proper strength. When a right-and-left ell is used, it is common to designate the left-hand-thread end in some way as is shown in the accompanying illustration, where this opening is ribbed.

Reducing ells are modified forms of the straight ell, in which one of the outlets is smaller than the other. These are always threaded right-handed, unless made

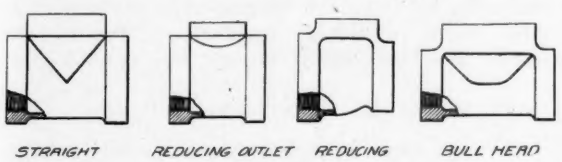



FIG. 3. FORMS OF TEES

to special order. The side outlet or 3-way ell is seldom used, except for connecting drips, owing to the difficulty in allowing for contraction and expansion, due to heat.

The street elbow derives its name from its most common use in connecting a service pipe of a water or gas system. It takes the places of an ell and a close nipple, being threaded with male and female threads. This fitting is convenient in places where a right angle turn must be made in close quarters and is sometimes used by steam-fitters in connecting water columns from the upper side of the boiler drum beneath the brick work where space is limited.

Tees, as the name implies, are fittings having 3 connecting outlets which take the form of the letter T. These are used to take branches from the main pipe at an angle of 90 deg. without changing the direction of the main run. Any number of branches may be taken from the main line by inserting tees in the line. Standard tees are always made with right-handed threads, but may be secured with left-hand threads by special order.

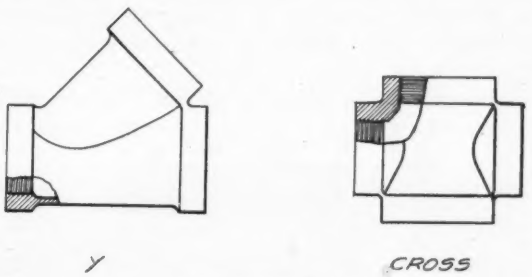



FIG. 4. Y AND CROSS

Tees may be secured with any standard size of opening for any of the outlets. In ordering it is necessary to designate the size of the run, then the size of the branch, as 1 by 1 in. or straight 1 in. if the run openings are of the same size. If not it is necessary to name the large run first, then the small run, then the branch, as 1½ by 1¼ by 1 in. When the branch is smaller than the main pipe the fitting is called a tee with a reducing outlet. The term reducing tee applies to fittings where the run is reduced in size as in the above case. "Bull-

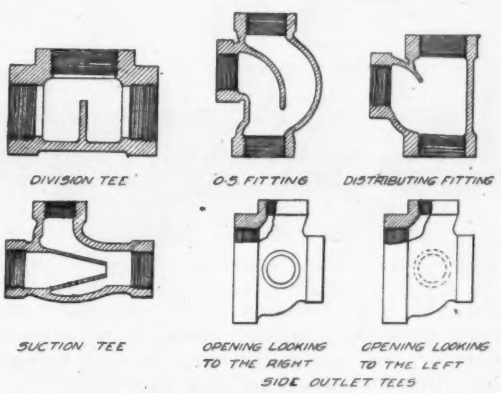



FIG. 5. SPECIAL FITTINGS

head" tees have the run smaller than the branch, and are used where the pipe branches both ways.

Y branches are in reality angle tees, that is, tees with a 45-deg. angle branch from the run of pipe. These are made in straight sizes; that is, with the openings all the same size as standard stock, but may be secured in reducing sizes by special order. Y branches are designated as are tees, as explained above.

Crosses are used where 2 branches opposite each other are taken from the main run and at 90 deg. from it. There is an objection to the use of crosses due to the interference of flow to the branches.

A special fitting known as a division tee is used to deflect the flow of the fluid to the branch, by this means delivering more to the branch than the main run. This is done by providing a partition part way across the run of the tee. A modification of the division tee is the O. S. fitting which has a curved partition, causing the branch to be favored. A similar fitting, but with a shorter partition, is the distributing fitting, which has a large body at the branch and a short deflector on the run. What is known as a suction tee has a conical nozzle, similar to an injector, pointing in the direction of the flow, which induces a flow through the branch pipe. The suction tee can be used to advantage in making up all connections on heating jobs. Where condensation returns to the boiler, they are recommended for connection where 2 returns come together; also where the pipes are in different sections, one section may be used to make the other circulate. They are also used where 2 or more connections are made to the same steam trap, as they will cause all the condensation to flow freely into the trap and avoid the trouble of one backing up on another. In this way, it is stated, one steam trap can be used to answer for several different connections, avoiding the necessity of putting steam traps on each return if all are from the same boiler.

DIMENSIONS OF STANDARD FLANGE PIPE FITTINGS
(All dimension are in inches and refer to letters in Fig. 6)

| Size | 1 | 1¼ | 1½ | 2 | 2½ | 3 | 3½ | 4 | 4½ | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 14 | 15 | 16 | 18 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AA | 7 | 7½ | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 20 | 22 | 24 | 28 | 29 | 30 | 33 | 36 |
| A | 3½ | 3½ | 4 | 4½ | 5 | 5½ | 6 | 6½ | 7 | 7½ | 8 | 8½ | 9 | 10 | 11 | 12 | 14 | 14½ | 15 | 16½ | 18 |
| B | 5 | 5½ | 6 | 6½ | 7 | 7½ | 8½ | 9 | 9½ | 10½ | 11½ | 12½ | 14 | 15½ | 16½ | 19 | 21½ | 22½ | 24 | 26½ | 29 |
| C | 1½ | 2 | 2½ | 2½ | 3 | 3 | 3½ | 4 | 4 | 4½ | 5 | 5½ | 5½ | 6 | 6½ | 7½ | 7½ | 8 | 8 | 8½ | 9½ |
| D | 7½ | 8 | 9 | 10½ | 12 | 13 | 14½ | 15 | 15½ | 17 | 18 | 20½ | 22 | 24 | 25½ | 30 | 33 | 34½ | 36½ | 39 | 43 |
| E | 5½ | 6½ | 7 | 8 | 9½ | 10 | 11½ | 12 | 12½ | 13½ | 14½ | 16½ | 17½ | 19½ | 20½ | 24½ | 27 | 28½ | 30 | 32 | 35 |
| F | 1½ | 1½ | 2 | 2½ | 2½ | 3 | 3 | 3 | 3 | 3½ | 3½ | 4 | 4½ | 4½ | 5 | 5½ | 6 | 6 | 6½ | 7 | 8 |
| G | | | | | | 6 | 6½ | 7 | 7½ | 8 | 9 | 10 | 11 | 11½ | 12 | 14 | 16 | 17 | 18 | 19 | 20 |
| H | 4 | 4½ | 5 | 6 | 7 | 7½ | 8½ | 9 | 9½ | 10 | 11 | 12½ | 13½ | 15 | 16 | 19 | 21 | 22½ | 23½ | 25 | 27½ |
| I | 7/16 | 1/2 | 7/16 | 1/2 | 5/8 | 5/8 | 5/8 | 5/8 | 5/8 | 1 | 1 1/16 | 1 1/16 | 1 1/16 | 1 1/16 | 1 1/16 | 1 1/16 | 1 1/16 | 1 1/16 | 1 1/16 | 1 1/16 | 1 1/16 |
| K* | 7/16 | 7/16 | 7/16 | 7/16 | 7/16 | 7/16 | 7/16 | 1/2 | 1/2 | 1/2 | 7/16 | 1/2 | 5/8 | 5/8 | 5/8 | 5/8 | 5/8 | 5/8 | 1 | 1 1/16 | 1 1/16 |
| L | 3 | 3½ | 3½ | 4½ | 5½ | 6 | 7 | 7½ | 7½ | 8½ | 9½ | 10½ | 11½ | 13½ | 14½ | 17 | 18½ | 20 | 21½ | 22½ | 25 |
| M | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 12 | 12 | 12 | 12 | 16 | 16 | 20 |
| N | 7/16 | 7/16 | 1/2 | 1/2 | 5/8 | 5/8 | 5/8 | 5/8 | 5/8 | 5/8 | 5/8 | 5/8 | 5/8 | 5/8 | 5/8 | 5/8 | 5/8 | 1 | 1 | 1 | 1 1/8 | 1 1/8 |

| Size | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 | 42 | 44 | 46 | 48 | 50 | 52 | 54 | 56 | 58 | 60 | 62 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AA | 40 | 44 | 46 | 48 | 50 | 52 | 54 | 56 | 58 | 60 | 62 | 64 | 66 | 68 | 70 | 74 | 78 | 82 | 84 | 88 | 90 |
| A | 20 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 37 | 39 | 41 | 42 | 44 | 45 |
| B | 31½ | 34 | 36½ | 39 | 41½ | 44 | 46½ | 49 | 51½ | 54 | 56½ | 59 | 61½ | 64 | 66½ | 69 | 71½ | 74 | 76½ | 79 | 81½ |
| C | 10 | 11 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| D | 46 | 49½ | 53 | 56 | 59 | | | | | | | | | | | | | | | | |
| E | 37½ | 40½ | 44 | 46½ | 49 | | | | | | | | | | | | | | | | |
| F | 8½ | 9 | 9 | 9½ | 10 | | | | | | | | | | | | | | | | |
| G | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 | 42 | 44 | 46 | 48 | 50 | 52 | 54 | 56 | 58 | 60 | 62 |
| H | 29½ | 32 | 34½ | 36½ | 38½ | 41½ | 43½ | 46 | 48½ | 50½ | 53 | 55½ | 57½ | 59½ | 61½ | 64 | 66½ | 68½ | 71 | 73 | 75½ |
| I | 1 1/16 | 1 1/16 | 2 | 2 1/16 | 2 1/16 | 2 1/16 | 2 1/16 | 2 1/16 | 2 1/16 | 2 1/16 | 2 1/16 | 2 1/16 | 2 1/16 | 2 1/16 | 2 1/16 | 2 1/16 | 3 | 3 | 3 1/16 | 3 1/16 | 3 1/16 |
| K* | 1 1/16 | 1 1/16 | 1 1/16 | 1 1/16 | 1 1/16 | 1 1/16 | 1 1/16 | 1 1/16 | 1 1/16 | 1 1/16 | 1 1/16 | 1 1/16 | 1 1/16 | 2 | 2 1/16 | 2 1/16 | 2 1/16 | 2 1/16 | 2 1/16 | 2 1/16 | 2 1/16 |
| L | 27½ | 29½ | 31½ | 34 | 36 | 38½ | 40½ | 42½ | 45½ | 47½ | 49½ | 51½ | 53½ | 56 | 58½ | 60½ | 63½ | 65 | 67½ | 69½ | 71½ |
| M | 20 | 20 | 24 | 24 | 28 | 28 | 32 | 32 | 32 | 36 | 36 | 40 | 40 | 44 | 44 | 44 | 44 | 48 | 48 | 52 | 52 |
| N | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ | 1½ |

*Minimum.
L—Bolt circle.
M—Number of bolts.
N—Size of bolts.

The side outlet tee is a fitting with connections for straight run and 2 branches at right angles to each other. These may be secured with any size of opening for standard pipe. When ordering side outlet tees with reduced openings care must be taken to designate the openings properly, and it is advisable to draw a sketch to accompany the order. It is customary to name the large run first, then the small run, next the large branch, then the small branch, stating whether right or left of the branch looking in the direction of run, as 2 by 1½ by 1¼ by 1 in., side outlet looking to right, or to left as illustrated.

### Flange Fittings

Whenever the piping is large, or the pressure within it is high, it is advisable to use fittings with flanged outlets. Standard flanged fittings are made in all the shapes mentioned above, the flange being cast direct to the body of the fitting. Fittings are made of cast iron, semi-steel or cast steel to suit the pressure carried in the pipes. In recent practice it is common to have the fitting welded directly to the pipe, the 2 being held together by bolts through flanges, while the edge of the contact faces are welded by means of the acetylene process. For this purpose wrought iron or steel piping is used, while the flanges fit loosely over the ends, which is an advantage in making up the pipe system. Flanges for pipe-fitting are similar in all respects to those used in straight piping which were described previously. In the accompanying table are the standard dimensions as adopted by the manufacturers of America, and the American Society of Mechanical Engineers for both low and high-pressure fittings.

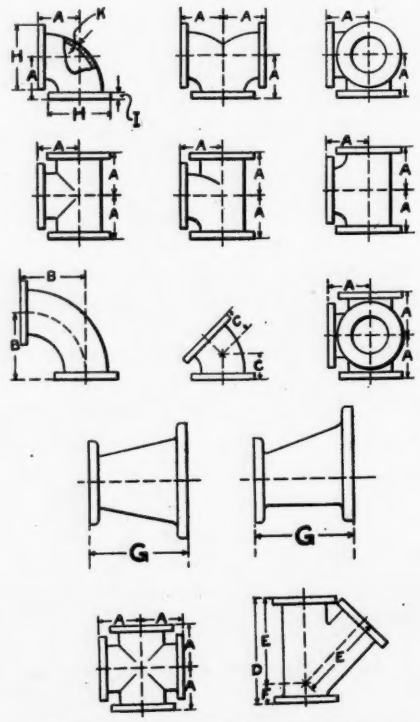



FIG. 6. STANDARD FLANGE FITTINGS

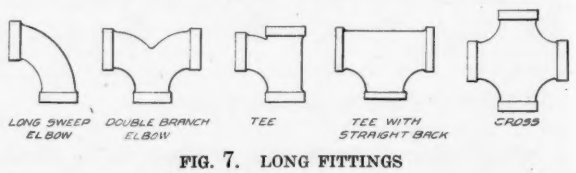



FIG. 7. LONG FITTINGS

### Long Sweep Fittings

With the standard fittings the radius of curvature is small, resulting in a quick turn of the fluid and considerable resistance to the flow. To overcome this loss, long sweep fittings have been designed, which have a

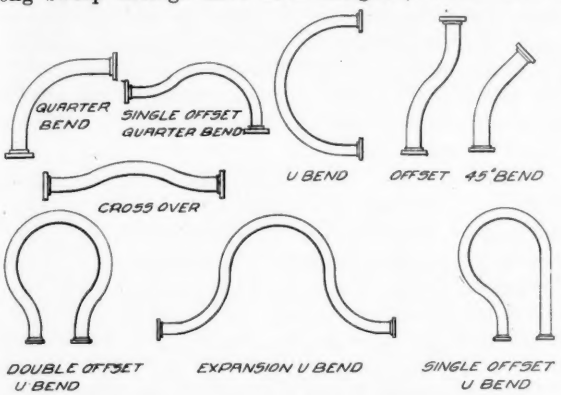



FIG. 8. STANDARD PIPE BENDS CARRIED IN STOCK

radius of curvature two times the ordinary fittings. The common fittings made up with a long sweep are ells, double branch ells, tees with straight backs and crosses. The illustration shows the shape of these fittings.

### Pipe Bends and Welded Nozzles

Where high velocity of flow is maintained and extreme economy in transmission is desirable, it is customary to employ pipe bends in preference to the standard fittings. These are usually made of lap welded steel pipe with flanged joints. They are made in special shapes to form offsets or cross-overs, or to care for expansions. As a rule pipe bends are made especially for the job at hand, but some shapes are carried in stock, such as are illustrated herewith, which are made by the Crane Co.

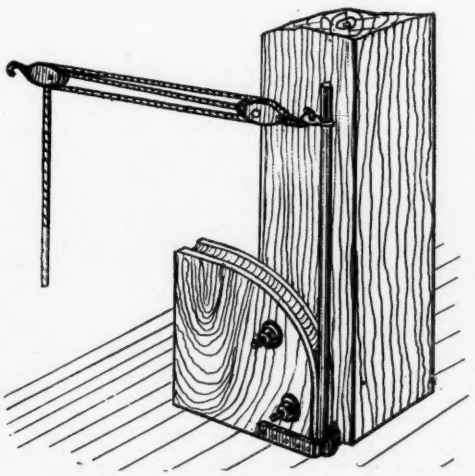


FIG. 9. METHOD OF BENDING SMALL PIPE

Where the pipe bends of large pipe are required, it is better to have the bending done at the shop in order to insure proper workmanship, but in small pipe work the bending may be done at the plant. The following method of bending a pipe has been used successfully, but of course, practice and care in manipulation give more perfect results. A post or column within the building is selected and to it is bolted a true plate sawed to the exact curvature of the circle desired. The edge of the wooden block is hollowed so that it conforms perfectly to the outside circumference of the pipe. This hollowing of the block prevents the pipe flattening on 2 sides as strain is put on the tackle. The pipe is placed in a vertical position and at the lower end a strong iron bar is bolted to the true plate to hold the front of the pipe rigidly. Hot sand is prepared, generally on a large sheet of iron nearby, and when it smokes it is poured into the pipe, filling it full, and a wooden plug is driven into the end of the pipe, sealing the sand perfectly. The block and tackle is attached to the pipe at its upper end and the pipe is pulled over the curve. As it bends, a workman gently strikes the curving surface with a hammer to assist the metal to take shape. The pull must be applied evenly or kinks will result. Much better results can be secured if the pipe is heated before putting in the hot sand, but it is difficult to handle a pipe in this condition.

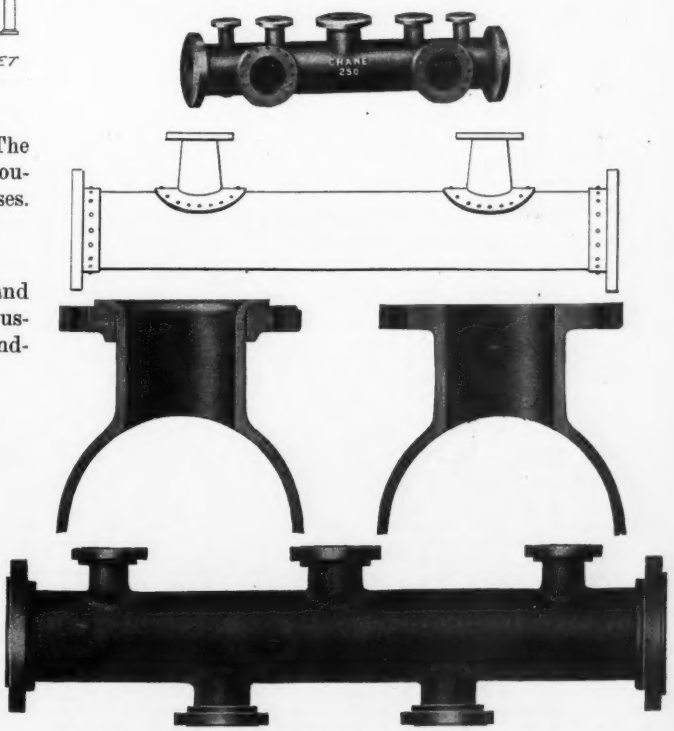



FIG. 10. TYPES OF MANIFOLDS: CRANE CO. CAST DISTRIBUTING HEADER, RIVETED NOZZLES, DETAIL OF WALWORTH WELDED NOZZLE AND WALWORTH WROUGHT STEEL HEADER

Due to the liability of imperfections in cast manifolds, the metal now commonly used for this purpose is wrought steel to which the nozzles are welded by the acetylene process, which insures homogeneous metal in the manifold and absence from leaks.

For lower pressures, cast manifolds and distributing headers are used, these being made of cast-iron, semi-steel or cast steel with flanged joints.

Another practice which is quite common is the riveting of the nozzles to the header, but it is frequently difficult to keep a tight joint due to the difficulty in calking the edges of the joints.

# Expansion in Piping

## How to Determine the Amount and Make Provision for It

With rise in temperature all metals expand in all directions, but the expansion in diameter of pipes is so small as to be of no consequence. The lengthwise expansion, however, must be taken care of in order to avoid excessive stress in the metal and straining at the joints.

The amount of expansion is proportional to the rise in temperature, to the length of the pipe, and to the coefficient of expansion, which varies with the temperature according to Table I, and is also different for each metal.

In using a value for the coefficient it should, therefore, be taken at about the average temperature at which the pipe will be used. Cast iron and brass piping are used mostly for feed water or exhaust. The coefficient would, therefore, be taken at around 200 deg., while for wrought iron and steel piping, largely used for steam, the coefficient should be chosen for an average of 350 deg. The coefficients for practical use in power plants have been so chosen, and the values are as given in Table II.

Since the length of the pipe run is usually measured in feet, it is convenient to express the formula for expansion in terms of the length of the pipe, in feet, and the rule is the total expansion, in inches, will be 12 times the coefficient of expansion from Table II times the length, in feet, times the temperature rise, or as a formula, $E=12\ C\ L\ (T_2—T_1)$. For ordinary conditions, $T_1$, the initial temperature, may be taken as 60 deg., and the value of $T_2$ for saturated steam will be that shown in the steam tables, corresponding to the pressure carried. For superheated steam the degrees of superheat must be added to the temperature of saturated steam in order to get the value for $T_2$.

This expression for expansion has been reduced for quick use to the form of a diagram, the left half of Fig. 1, the axis on the left-hand side showing the temperature rise, with a secondary scale which corresponds to the rise for a given boiler pressure and saturated steam above an initial temperature of 60 deg. The method of using this diagram is indicated by the dotted line. For a boiler pressure of 150 lb., start from the left-hand axis and follow horizontally to the diagonal for the pipe material to be used, in this case steel, then follow vertically to the diagonal corresponding to the length of the pipe run, in this case 150 ft., and then to the right to the middle axis, where the total expansion in inches will be read, in this case amounting to about 3.63 in.

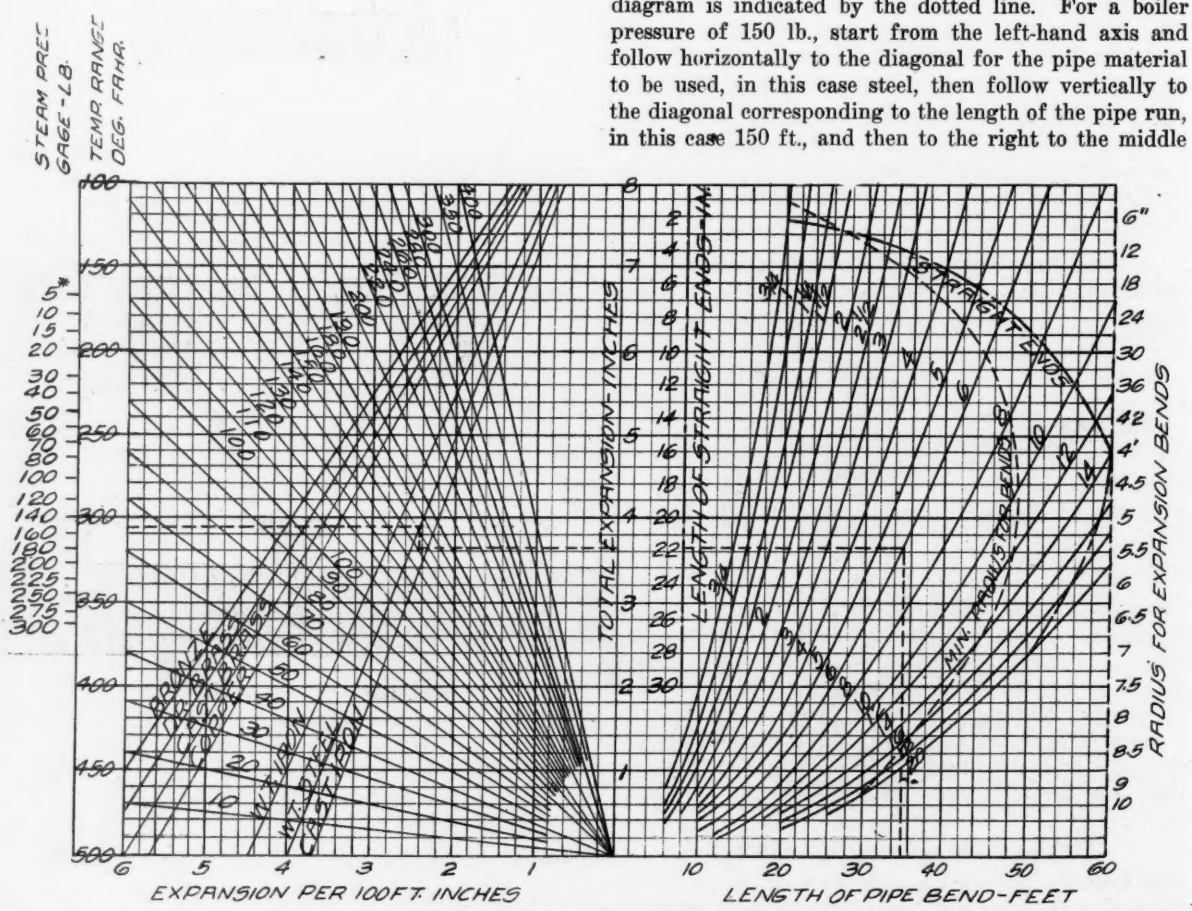



FIG. 1. DIAGRAM FOR EXPANSION OF PIPE AND LENGTH OF EXPANSION BENDS NEEDED

The National Tube Co. recommends that approximate allowance for iron pipe be 1 in. per 50 ft. of run, when providing expansion joints or pipe bends to take care of the expansion. From the diagram it will be noted that this corresponds to a temperature rise of 250 deg. for steel pipe, and 220 deg. for wrought iron pipe, so that it will be about right for saturated steam between pressures of 40 and 130 lb.

Three methods are in use for taking care of expansion—the swing joint, the pipe bend and the expansion joint. Each has its uses, but the swing joint is probably the least useful of the three. In any case, the swing joint, which is only applicable to screwed joints, should be used only for pipe 6 in. in diameter or smaller and where the expansion is limited in amount, generally for low-pressure work. It is accomplished by an offset in the pipe, which may be a single offset as indicated in the figure, if such is permissible in the pipe run, or if the pipe must be continued in the same line as the original run, a return offset must be made, which would be the reverse of the one shown. The intent is, that the expansion shall be taken up by the movement between fittings and pipe ends at the joints, but observation shows that in most instances there is no such movement, and the expansion is taken up by the bending and twisting of the pipe lengths in the offset.

TABLE I. VARIATION OF COEFFICIENT OF EXPANSION WITH TEMPERATURE

| Temp. deg. F. | Cast Iron | Wrought Iron | Brass |
|---|---|---|---|
| 50 | 0.00000580 | 0.00000638 | 0.00000927 |
| 100 | 0.00000600 | 0.00000660 | 0.00000960 |
| 200 | 0.00000626 | 0.00000688 | 0.00001002 |
| 300 | 0.00000660 | 0.00000726 | 0.00001056 |
| 400 | 0.00000700 | 0.00000770 | 0.00001120 |
| 500 | 0.00000740 | 0.00000814 | 0.00001184 |
| 600 | 0.00000791 | 0.00000871 | 0.00001266 |
| 700 | 0.00000855 | 0.00000941 | 0.00001368 |

### Pipe Bends

For most cases, pipe bends offer a satisfactory and economical method for taking up expansion, but the difficulty is to provide room for them, since in order to avoid strain on the fittings and excessive stress in the bends, a considerable length of pipe must be used, especially in large sizes. The bends have the advantage over the offset method of saving in the number of joints required, saving in the length of pipe and decrease in the cost of erection.

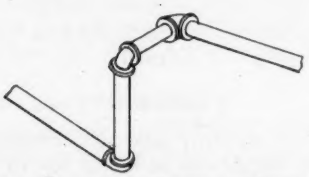


FIG. 2. SINGLE SWING OFFSET

Expansion is taken care of entirely by the spring in the pipe, and it makes no difference whether a straight length of pipe be employed, if this is possible, as in the case of turning a 90-deg. corner, or whether the required length of pipe to take up the spring is fashioned into a bend of one of the forms shown herewith and under return bends on a preceding page. In any case, the bend to take up the expansion should be made from a single length of pipe, if possible. This is limited in the case of curved bends, by the radius to which the bend may be made. This should be 6 diameters of the pipe, which limits the use of the U bend in a single length to 12-in. pipe or under, since the pipe ordinarily comes in lengths of not over 20 ft. In the case of the double bend or the loop, it will limit the single length construction to 6-in. pipe or smaller, and if such a form of bend is required in larger pipe, it must be made up of 2 or more lengths with a joint at the middle of the bend. For constructional reasons, there should be a straight end beyond the curve in any form of bend, of a length 1 to 2 times the diameter of the pipe, the larger figure being used for large pipe; and for joining bends to the pipe line or for making joints in bends, extra heavy flanges should be used with Van Stone joints, or with the flanges welded to the pipe.

TABLE II. COEFFICIENTS OF EXPANSION AT COMMON TEMPERATURES FOR PRACTICAL USE

| | |
|---|---|
| Bronze | 0.0000111 |
| Brass | 0.0000105 |
| Cast Brass | 0.0000100 |
| Copper | 0.0000095 |
| Wrought Iron | 0.0000075 |
| Steel | 0.0000072 |
| Cast Iron | 0.0000062 |

There is always tendency to spring the ends of the pipe run horizontally if a bend is laid horizontal, or vertically if the bend is installed vertical. The horizontal spring may be inconvenient if the ends of the pipe run are rigidly held, while the lifting due to the action of a vertical bend has but little inconvenience, but the vertical bend forms a pocket, which will prevent the passage of condensation and must be carefully drained.

As already stated, the expansion which can be taken up by a bend depends on the length of pipe in the bend and not on the shape. An extended discussion of this was given by Taggart in the Transactions of the American Society of Civil Engineers for December, 1910, and curves worked out for the permissible strain in the pipe considered as a beam, with an outside fibre stress of 12,000 lb. to the square inch, which gives a factor of safety of 5.

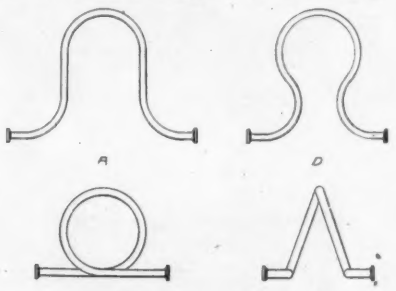



FIG. 3. SPECIAL FORMS OF EXPANSION BENDS: A RETURN; B CIRCLE; C TWIST LOOP; D FULL LOOP

The length necessary in the expansion bend will depend not only on the expansion in the straight run, but also on cross expansion of branches which may tend to deflect the main run. It is, therefore, desirable, in the installation of piping, to anchor the main run close to the point where a branch is taken off, and provide for taking up the expansion of the branch away from the

main run of pipe. If an expansion bend is installed in the middle of a run of pipe, the center of the bend should be anchored and the bend take up the expansion both ways from the middle. It is usually better, however, to install the expansion bend at the end of the run of pipe or close to an anchor and let all expansion be taken in one direction. In making up the bend, care should be taken that the seam is on the side of the bend, so that it is subjected neither to compression nor tension when making the bend.

### Length of Bends

Along the line of Taggart's discussion, Raynes gives us a formula for the length of pipe to take up the expansion of a given run, the following: $l = K\sqrt{d \times L \times t}$; where l is the length, in feet, of pipe to take up expansion; d is the external diameter of the pipe, in inches; L is the length of the expanding run, in feet; t is the temperature rise; K is a constant whose value for wrought iron and steel is 0.043; for cast iron, 0.057.

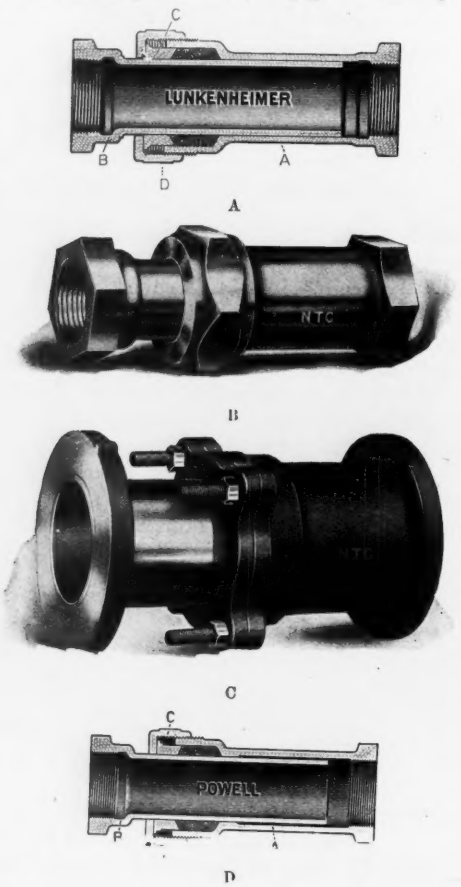



FIG. 4. SIMPLE SLIP EXPANSION JOINTS: A LUNKENHEIMER, BRASS BODY; B NATIONAL TUBE CO., IRON BODY; C, NATIONAL TUBE CO., FLANGED ENDS; D POWELL

Taggart's values, where the arrangement is such that cross expansion may be neglected, have been embodied in the curves of the right-hand side of Fig. 1 to permit of direct reading of the length required in the pipe bend. To show the use of these curves, for a main run of 150 ft. of 6-in. pipe to carry steam at 150 lb. pressure, we have, as shown on the left-hand side of Fig. 1, to care for an expansion of 3.63 in. We wish to install a circle bend to take care of this expansion, and from the middle axis of Fig. 1, follow to the right to the curve for 6-in. pipe, and vertically down to the horizontal axis it shows that a length of approximately 35 ft. must be provided in the bend. This is greater than the single length of pipe, so that 2 sections must be used with a joint at the center. It would be better to use 2 full lengths of 40 ft. in the bend.

The minimum radius of 5 times the diameter of the pipe would be 30 in., which would give a semi-circle having a circumference of about 8 ft. We must, therefore, use a radius larger than this in order to include 40 ft. in the circle bend. If we use a 60-in. radius, the length of the semi-circle will be 15 ft. 9 in. To this there must be added 7 in. for the straight end next to the center joint, which will, of course, give an elliptical bend instead of circular. This will be a length of 16 ft. 4 in., which, taken from the 20 ft. of a full pipe length, would give 3 ft. 8 in. as the horizontal leg to connect to the main run. This will give a convenient form for erection and will, therefore, be satisfactory. The loop is shown at A, Fig. 14.

The cross curves on the right-hand side of Fig. 1 show the minimum radius for bends for the different size pipes, indicated on the axis to the right, and the length of each straight end to be allowed beyond the bent portion indicated on the short axis to the left. For instance, for the 6-in. pipe where the straight end curve crosses the 6-in. curve, follow to the left and we find about 7 in. as the straight end required. Where the minimum radius curve crosses the 6-in. curve, follow to the right and we find about 30 in. as the minimum radius for the bend.

One difficulty in the use of bends in large pipe—that is, the great length required to take up expansion of a run of considerable length—may be overcome by using a multiple branch bend between 2 headers. The area of the several pipes in the bend should equal or exceed the area of the main line, but the expansion taken care of by the bend may be the same as if there were a single pipe of smaller diameter. For instance, a 12-in. pipe, for the conditions of the above problem, would require 48.5 ft. in the bend, while by using 6-in. pipe, 4 branches each 35 ft. long would be used.

### Cold Spring

A method frequently used for increasing the amount of expansion which can be cared for by a bend or by the straight length at a 90-deg. turn, is the cold spring when installing the piping system. If the run of pipe be cut short by, say, one-half the amount of the expansion at maximum temperature, and the pipe be sprung by this amount when erecting cold so as to put the pipe under tension, the part of the pipe which takes up the expansion may then care for double the amount which it could if no cold springing were used. The amount of cold spring may even be made equal to the entire amount of expansion if the arrangement of the piping system will permit. Thus, the joints and fittings will be put under a tension when cold and with no steam pressure on the system, and will be relieved of all tension due to springing of the pipe when the system is in

use and the steam pressure at the maximum. This method of cold spring must be used, however, with judgment, and it must be remembered that it is impossible to stretch pipe lengthwise when erecting it. The cold spring must be taken up by the bending of pipe either where the pipe run changes direction or by the insertion of expansion bends.

### Expansion Joints

Of these one form has a sleeve sliding in a stuffing box; the other form takes up the movement by the spring of a diaphragm.

When installing a slip joint it should be remembered that the sleeve must be at its extreme outer permissible position when the joint is installed, since the sleeve moves inward in the stuffing box as the pipe expands. The details of several joints as found on the market follow:

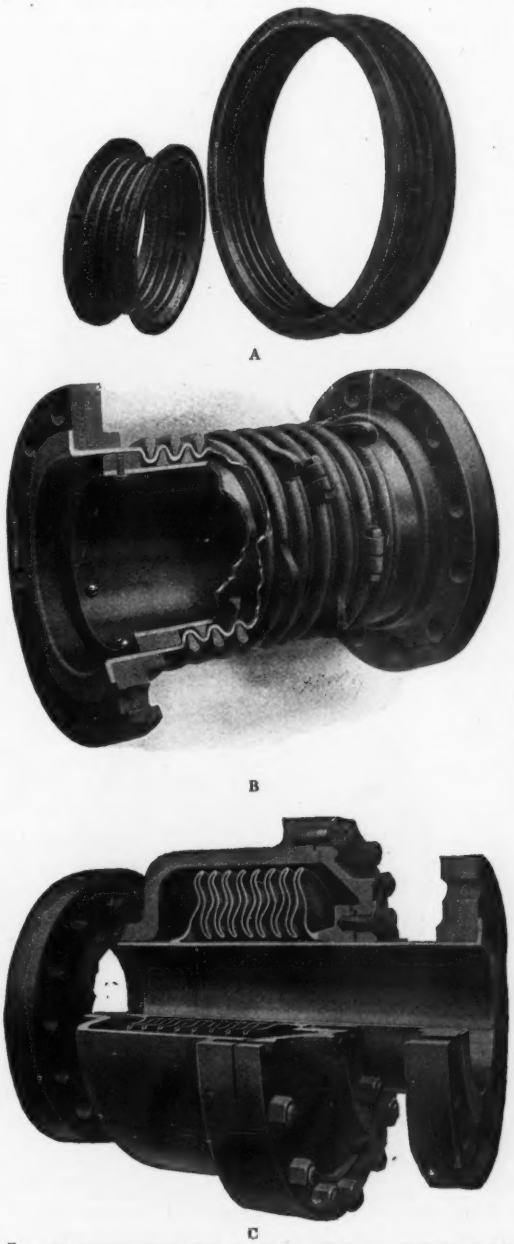
A simple form of expansion joint is made in brass by the National Tube Co., the Lunkenheimer Co. and the Wm. Powell Co. in sizes for pipe from ½ in. to 3 in., for pressures up to 125 lb. and with 2 to 3-in. traverse. The ends are screwed and stuffing box fitted with a gland nut. Special joints may be had for sizes from ¾ in. to 2½ in. with traverse from 4 in. to 12 in.

The same companies also make iron-body expansion joints with brass sleeves having the ends either screwed or flanged. They are for 2-in. to 12-in. pipe with standard traverse running from 2½ up to 8 in. and special with traverse from 6 to 18 in. The glands for stuffing-boxes are tightened by stud bolts, 3 being used on the smaller sizes and 4 on the larger.

Wainwright expansion joints made by the Alberger Condenser Co. are of two types, the expansion in both being cared for by the elasticity of a corrugated copper pipe. The ends of the pipe are turned out over plain flanges and butt against the companion flange or gasket to make the joint. For low pressures up to 20 lb., no reinforcement of the copper is needed; but for high pressures, up to 160 lb., an inner slip tube of hard composition is used, having triangular equalizing rings of cast iron to fit into the corrugations of the copper tube and equalize the play so that each corrugation takes its share of the travel. For very high pressures, reinforcing rings are placed in the outside grooves of the copper to assist in carrying the steam pressure and in equalizing the movement.

For pressures above 160 lb., the steel expansion joint, Fig. 5C, is recommended up to 200 lb. pressure. This has a heavy cast-iron casing which carries one connecting flange and protects the working portion of the joint. Circular disks are stamped from steel plate of high elastic limit, are corrugated and the edges welded together forming the bellows, which has one end welded to the tube and the other to a sleeve. By this construction only the outside of the bellows is exposed to steam and no condensation can collect on the inside. Half the expansion is taken up by "cold strain," the flange being forced out from neutral position to half the limit of motion for the joint by spacers, and the device installed with these spacers in position.

For large sizes of pipe in low pressure lines, American District Steam Co. has a series of slip expansion joints either single or double end, supplied with anchor feet and with outlet taps at the sides of the top. The slip tubes are of brass with packed stuffing boxes and water seal, packing glands being held by stud bolts. Each slip tube has a traverse of 3.5 to 4 in. to care for expansion in 100 to 150 ft. of pipe.



A B C

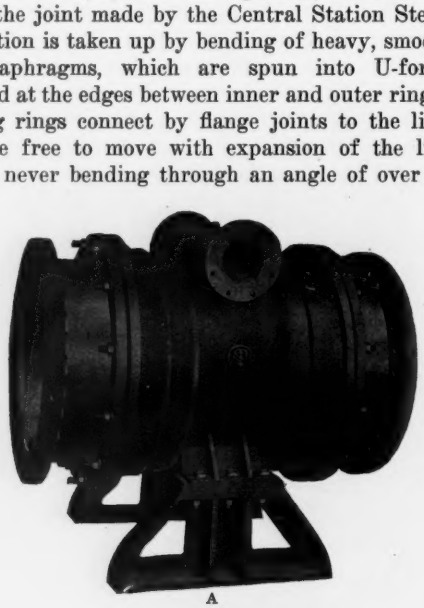
FIG. 5. WAINWRIGHT EXPANSION JOINTS: A FOR LOW PRESSURE; B FOR HIGH PRESSURE; C FOR EXTRA HEAVY PRESSURES

Another type of expansion joint, made by the American District Steam Co., is the double variator, which consists of 2 corrugated copper diaphragms, and is capable of caring for the expansion of 50 ft. of pipe. It was designed and is largely used for underground heating mains, and after once being in place, requires no further attention.

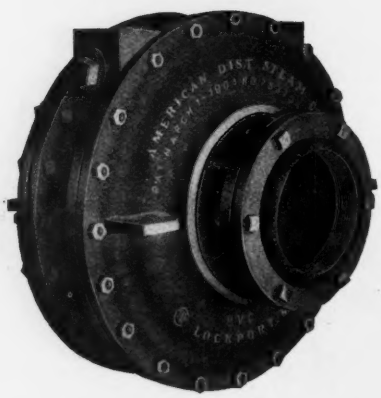
Badger self-equalizing expansion joints, made for low or high pressures by E. B. Badger & Sons. Co., are

made of one piece of rolled corrugated copper, with ends turned over flanges and equalizing rings of cast iron or steel to strengthen the joint and distribute the expansion equally among all corrugations. Each corrugation is capable of caring for ½ in. of expansion and the joints are made with 2, 3, 4 or 5 corrugations, as needed.

In the joint made by the Central Station Steam Co., the motion is taken up by bending of heavy, smooth copper diaphragms, which are spun into U-form and clamped at the edges between inner and outer rings. The backing rings connect by flange joints to the line pipe and are free to move with expansion of the line, the copper never bending through an angle of over 10 deg.



A



B

FIG. 6. AMERICAN DISTRICT STEAM CO. JOINTS: A SLIP JOINT; B VARIATOR TYPE

With the pipe cold, the backing ring is in outer position resting against the lip of the outer ring; as the pipe expands, the backing ring moves toward the center of the joint, the copper bending against the ring, until at extreme inward position the backing ring rests against the inner ring, preventing further motion. Each diaphragm will care for an expansion of 1¼ in. or 50 ft. of line.

For low-pressure lines, up to 25 lb., Crane Co. makes two forms of copper expansion joints. In the first, the copper is spun to a convex oval form, with the ends turned over flanges, and a drip outlet provided. The flanges can be turned on the copper, thus making it easy to aline the bolt holes while keeping the drip at the bottom. In the second form, which is especially adapted to high vacuum systems as the form resists collapse, the copper shell is in U-form with split rings for bolting to flanges on the pipe line. Both styles are made for pipe from 4 in. to 48 in.

Crane Co. also makes double expansion slip joints for pressures up to 125 lb., with iron body and brass sleeves, and with anchor base. They have stuffing-boxes and bolted glands, traverse of 4 in. for pipe from 2 in. to 9 in. and of 3½ in. for pipe 10 in. to 16 in., and may be had with side outlets where needed.

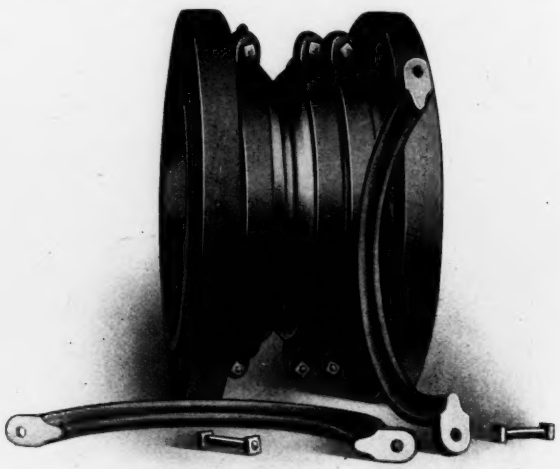


FIG. 7. BADGER REINFORCED EXPANSION JOINT

For pressures to 250 lb., the Crane heavy expansion joints have tie rods to prevent excess outward motion of the sleeves. The traverse runs from 2.5 in. for 2-in. pipe to 10 in. for 18-in. pipe, and special traverse can be had up to 16 in. for sizes from 2-in. to 8-in. pipe. Another type of extra heavy joints has balancing plungers which take pressure in a direction to oppose the forcing apart of the joint, thus leaving the sleeve free to move with expansion of the line. The bodies are standard of cast iron, but are made of ferrosteel or cast steel for special work. Traverse is standard at 6 in. for

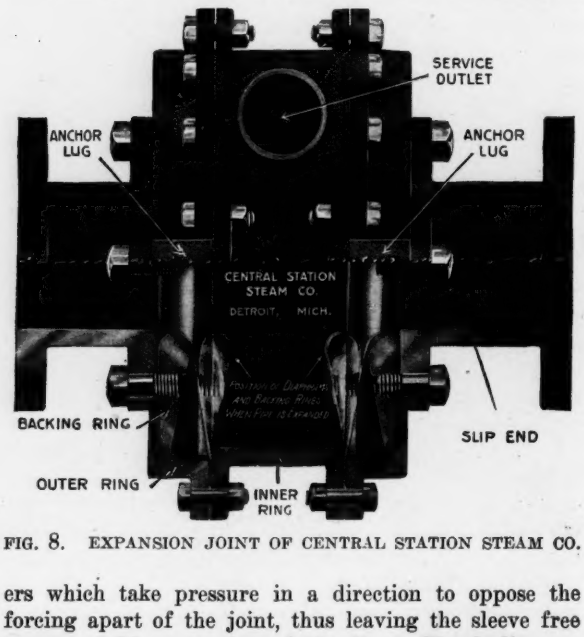



FIG. 8. EXPANSION JOINT OF CENTRAL STATION STEAM CO.

all sizes from 4 in. to 14 in., but any length traverse can be had on order.

For low-pressure work only, vacuum or not over 15 lb., the Griscom-Russell Co. has an expansion joint consisting of corrugated copper pipe formed from flat sheets and with joint carefully brazed. It may have one or more corrugations, the ends being slipped through flanges and turned back on the faces of the flanges so that the edge is just inside the bolt holes. The range of sizes is from a few inches to 12 ft. diameter and the joint may be made round, elliptical, rectangular or of irregular shape in section when desired. Besides expansion, this joint serves to take up vibration in such locations as connecting steam turbines and condensers.

In the guided expansion joint made by the Howard Iron Works, the outer sleeve is machined on the inside surface and the flanges which travel in it are machined on their peripheries, thus giving perfect alinement, to the bronze slip tube, relieving the packing of wear and avoiding sticking, or sagging of the line at

FIG. 9. CRANE CO. JOINTS: A CONVEX FORM; B U FORM; C LOW PRESSURE SLIP JOINTS; D BALANCE- PISTON JOINT

the joint. The guide also protects the packing from grit and oil so successfully that over a period of years on a system using 40 fittings, no repacking or tightening of glands has been necessary. If repacking becomes desirable, the guide can be unbolted and slipped off over the flanges onto the pipe line, leaving the gland accessible. This expansion fitting is especially designed for bolting to a foot elbow, tee or cross which will act as an anchor, or an anchor base may be had cast on the smaller end of the joint. Also, if a double joint is used, service outlets may be taken from the middle chamber. Standard traverse of the single joint is 4 in.

The Howard Iron Works also makes plain expansion joints with screwed or flanged ends in single or double type, and extra heavy joints with tie rods for high pressures.

Ross Heater & Mfg. Co. makes a crosshead-guided expansion joint as shown in the illustration, which is designed to maintain alinement, prevent sagging and wear on the packing in the stuffing-box which preserves the joint tight against leakage. This joint is made single to care for 4 or 8 in., or double form for 8 and 16-in. expansion, every variation in length of pipe line being taken care of without exerting pressure on the pipe. Guide and body are heavily ribbed to give rigid-

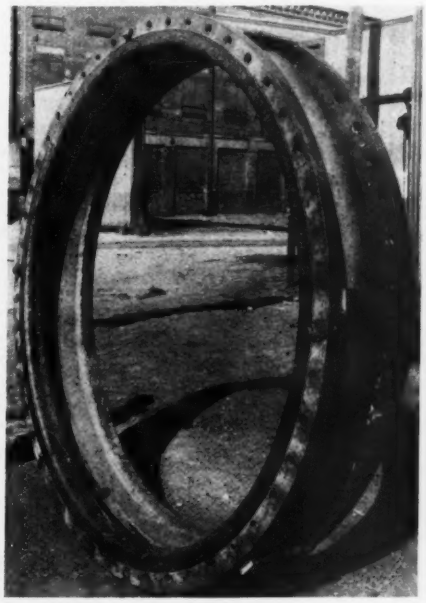


FIG. 10. GRISCOM-RUSSELL LOW-PRESSURE JOINT FOR 84-IN. PIPE

ity. This joint is suitable for moderate pressures, and for superheat and higher pressures a special joint is made with motion limited by the rods.

For swivel joints in lines where expansion can best be handled by offsets, Walworth Mfg. Co. has a line of joints for pipe from 3 in. to 7 in., made in cast-iron with brass bearing ring for pressures up to 250 lb. and in cast steel with monel metal bearing ring for pressures to 350 lb. and temperatures to 800 deg. F. The con-

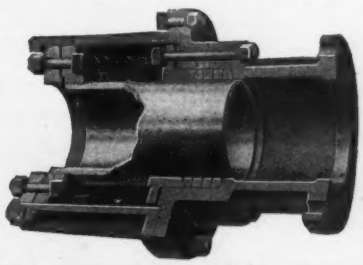


FIG. 10A. HOWARD IRON W'K'S GUIDED JOINT

struction is as indicated in the sectional view, Fig. 12, the sleeve being provided with stuffing-box and gland to insure a tight joint.

### ANCHORING PIPES

PIPES ARE anchored for 2 purposes—crosswise anchoring to prevent or lessen vibration, and lengthwise anchoring to insure the permanent position of the pipe at some one or more points, and to throw the expansion in the direction desired. Various forms of anchors are shown in Fig. 13. The anchor must be firmly fastened to

some rigid part of the structure, such as a beam or column, and for preventing endwise movement should be of such form as to permit sidewise motion of the pipe in all directions; for stopping vibration, the anchor should prevent sidewise motion in the direction in which the vibration takes place, but should permit endwise motion of the pipe due to expansion. The anchor for vibration should be placed at the point of the greatest amplitude of the vibration, and should usually be accompanied by the introduction of long radius bends at any nearby points where the pipe changes direction, and by the installation of a receiver of large volume at the end of the pipe run.

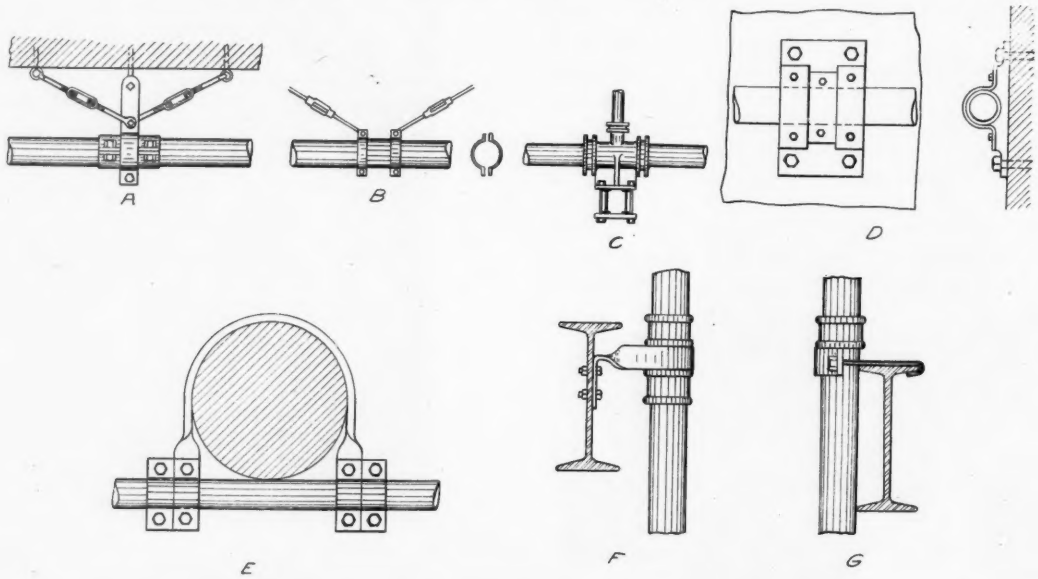



FIG. 13. TYPES OF ANCHORING FOR PIPES: A AND B SUSPENSION ANCHORS; C ANCHOR TEE; D WALL SUPPORT AND ANCHOR; E ANCHOR TO COLUMN; F AND G ANCHORS FOR RISERS

In installing anchors and supports for piping, it is necessary to allow for the expansion of cross branches so that there may be sufficient length to take up the expansion by the spring of the pipe. An example will illustrate this. Referring to Fig. 14, the main line is anchored close to the tee where the 5-in. branch is taken off, and it is intended that the expansion of the branch shall be taken up to the right, away from the main line. This is 30 ft. in length of 5-in. pipe, and the curves of Fig. 1 show that this will call for an expansion of 0.75 in. The anchor on the second run of 2-in. pipe must, therefore, be placed far enough from the end of the 5-in. line so that the spring of the 2-in. pipe beyond the anchor may take care of this 0.75-in. expansion. From the diagram, Fig. 1, it is seen that to take care of 0.75-in. expansion will require 9.5 ft. of 2-in. pipe, so that the anchor must be placed 9.5 ft. from the tee where the 5-in. pipe connects to the 2-in. The supporting saddle on the 5-in. pipe must be placed sufficiently to the left of this joint to permit of the 5-in. pipe taking up the expansion due to the 9.5 ft. of 2-in. pipe between the joint and the anchor. The curves show that 10 ft. of 2-in. pipe will have an expansion of 0.25 in., and that to take up this expansion will require 6 ft. of 5-in. pipe; therefore the supporting saddle must be placed 6 ft. from the tee. It is intended, of course, that the expansion of the 4-in. line will be taken up in the bend where it changes direction.

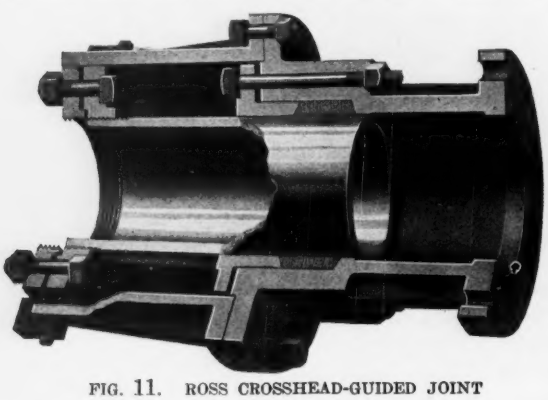


FIG. 11. ROSS CROSSHEAD-GUIDED JOINT

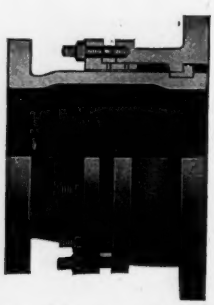


FIG. 12. WALWORTH SWIVEL JOINT FOR LARGE PIPE

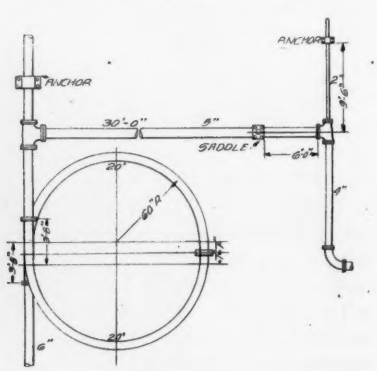



FIG. 14. ANCHORING AND ALLOWANCE FOR BRANCH EXPANSION

# Pipe Covering

## Loss Due to Heat Radiation and Materials Used for Insulation

IT has been experimentally determined that each square foot of bare pipe surface will radiate about 3 B.t.u. per hr. for each degree F. difference between the temperatures of the steam and the outside air, the exact amount varying with the velocity and humidity of the air. If, in any particular case, the essential conditions are known, the heat loss can be estimated in terms of dollars and cents. It will be necessary to determine the square feet of exposed pipe surface; the temperature of the steam subtracted from the average temperature of the surrounding air, will give the temperature difference. Conditions of operation of the plant will approximately determine the number of hours which steam will be in the pipe line during a period of one year. These factors will give the total B.t.u.'s lost during the year, and this amount divided by 970.4 will give the number of pounds of steam from and at 212 deg. equivalent to this loss. The evaporation per pound coal and the cost of coal per ton (including cost of handling it and ashes) being known, the money value of the loss is easily derived.

Expressed in a formula:

Loss per year due to steam condensed =

$$\frac{3\ A\ (t - t_1)\ N \times C}{970.4 \times 2000\ E}$$

In which A = sq. ft. of pipe surface exposed; t = temperature deg. F. of steam; $t_1$ = average temperature deg. F. of surrounding air; N = number of hours per year steam is in the pipe line; E = evaporation from and at 212 deg. F. per lb. of coal; C = cost of coal and handling, per ton of 2000 lb. Latest practice relates the cost of covering to the resultant saving of condensation; that is, the initial charge plus depreciation and interest on the investment for pipe covering should not exceed the saving which corresponds to the decrease in condensation losses. In general, however, conditions are such that the saving outweighs by a large margin the cost of a pipe covering of proper thickness.

### Materials for Covering Pipes

Pipe covering may be either "sectional," that is, molded to the shape of the pipe and attached by means of bands; or "plastic," which is mixed in the form of mortar, and placed on the pipe in layers. Sectional covering is usually made in 3-ft. lengths.

Asbestos diatomaceous earth and magnesia are the insulating substances most commonly used, because of their heat-resisting qualities, but cork, hair felt and mineral wool are also poor conductors of heat. Standard covering consists of 85 per cent of carbonate of magnesia mixed with 15 per cent of asbestos or its equivalent.

For high-pressure pipes from 2 to 8 in. in diameter, the covering should be from 1½ to 2½ in., the thickness varying according to size. A thickness of 3 in. is used on lines over 8 in. in diameter. For smaller lines and low-pressure piping 1 in. is sufficient. In low-pressure steam and hot water lines, wool felt in combination with asbestos has been found to give satisfactory service. Other forms are constructed with layers of corrugated asbestos paper using the principle that still air is a poor conductor of heat.

L. B. McMillan, in the Journal of the A. S. M. E., offers the results graphically recorded in Fig. 1, which were derived from the extensive conductivity tests with various forms of commercial covering. This chart shows the heat loss in B.t.u. per degree temperature difference per sq. ft. per hr. of some of the coverings which are briefly described herewith. Statements as to whether the coverings was recommended for high or low pressure or superheated steam pipe were furnished by the manufacturer, and are not conclusions drawn from the tests. The weight per foot in each case is the average weight per lineal foot of 5-in. pipe covering, and the thickness given is the average thickness.

1: J-M 85 Per Cent Magnesia. Molded sectional covering for high pressure steam pipes; 85 per cent by weight of magnesium carbonate and the remainder principally asbestos fiber. Weight per foot, 2.92 lb. and thickness 1.08 in.

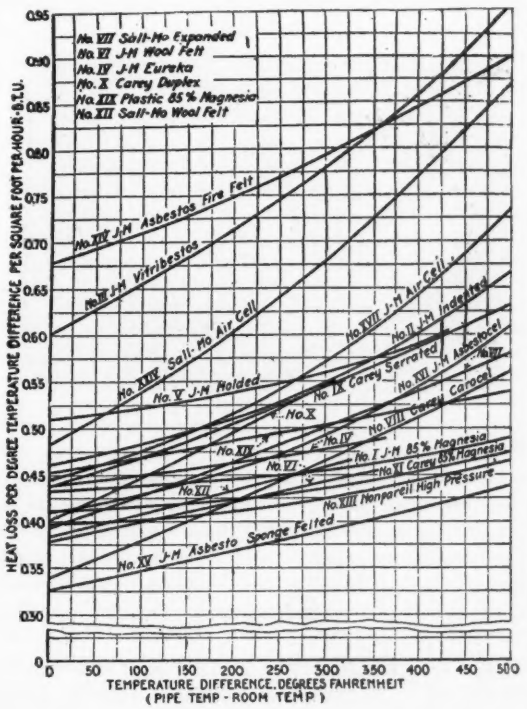



FIG. 1. SUMMARY OF RESULTS OF SINGLE THICKNESS COVERING

2: J-M Indented. Layers of asbestos felt with indentations, about 1¼ in. in diameter and ⅛ in. deep, spaced very close to each other in staggered rows. For pipes containing high pressure steam. Weight per foot, 3.46 lb. and thickness 1.12 in.

3: J-M Vitribestos. Asbestos air cell covering made of alternate layers of smooth and corrugated vitrified asbestos sheets. Corrugations about ¼ in. deep and run lengthwise of the pipe. For use on high-pressure and superheated steam pipes and for stack liners, etc. Weight per foot, 4.05 lb. and thickness, 0.96 in.

4: J-M Eureka. For low pressure steam and hot water pipes. Made of ¼ in. of asbestos felt on the

inside of the section and the balance of alternate layers of asbestos and wool felt. Weight, 4.60 lb. per ft., and is 1.04 in. thick.

5: J-M Molded Asbestos. Molded sectional covering for use on low and medium pressure steam pipes. Made of asbestos fiber and other fire-proof material. Weight per ft. 5.53 lb. and thickness is 1.25 in.

6: J-M Wool Felt. A sectional covering made of layers of wool felt with an interlining of 2 layers of asbestos paper. May be used on low pressure steam and hot water pipes. Weight per ft. 2.59 lb. and thickness 1.10 in.

7: Sall-Mo Expanded. A covering for use on high and low pressure steam pipes. Made of 8 layers of material, each consisting of a smooth and a corrugated piece of asbestos paper, the corrugations being crushed down to form small longitudinal air spaces. Weight, 3.47 lb. per ft., and thickness, 1.07 in.

8: Carey Carocel. Composed of plain and corrugated asbestos paper firmly bound together. Corrugations are approximately ⅛ in. deep and run lengthwise of the pipe. For use on medium and low-pressure steam pipes. Weight 3.06 lb. per ft. and thickness 0.99 in.

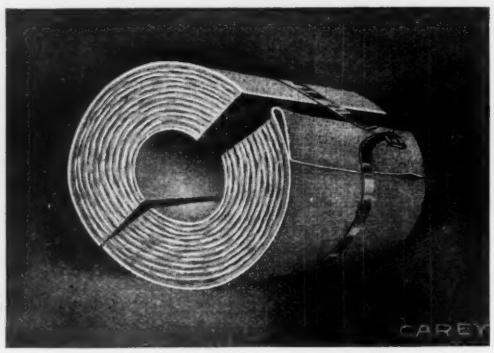



FIG. 2. CAREY SERRATED PIPE COVERING

9: Carey Serrated. For high pressure steam pipes. Composed of successive layers of heavy asbestos felt having closely spaced indentations. Weight 5.66 lb. per ft. and thickness 1.00 in.

10: Carey Duplex. For low pressure steam and hot water pipes. Alternate layers of plain wool felt and corrugated asbestos paper firmly bound together. Corrugations run lengthwise and make air cells approximately ¼ in. deep. Weighs 1.79 lb. per ft., and is 0.96 in. thick.

11: Carey 85 Per Cent Magnesia. For high pressure steam and similar in composition to No. 1. Weight per foot 2.74 lb. and thickness 1.10 in.

12: Sall-Mo Wool Felt. Similar to No. 6, except without interlining asbestos paper. For low pressure steam and hot water pipes. Weight per foot, 3.73 lb., and thickness 1.01 in.

13: Nonpareil High Pressure. Molded sectional covering consisting mainly of silica in the form of diatomaceous earth—the skeletons of microscopic organisms. For high pressure and superheated steam pipes. Weight 2.96 lb. per ft. and is 1.16 in. thick.

14: J-M Asbestos Fire Belt. Asbestos fiber loosely felted together, forming a large number of small air spaces. For high pressure and superheated steam pipes. Weight per ft. 3.75 lb. and thickness 0.99 in.

15: J-M Asbestos Sponge Felted. Made from a thin felt of asbestos fiber and finely ground sponge, forming a very cellular fabric. Forty-one of these sheets per inch thickness; air spaces are formed between the sheets in addition to those in the felt itself. Specially recommended for high pressure and superheated steam pipes. Weight per ft. 4.04 lb. and thickness 1.16 in.

16: J-M Asbestocel. For medium pressure steam and heating pipes. Alternate sheets of corrugated and plain asbestos paper, forming air cells about ⅛ in. deep that run around the pipe. Weight per ft. 1.94 lb. and thickness 1.10 in.

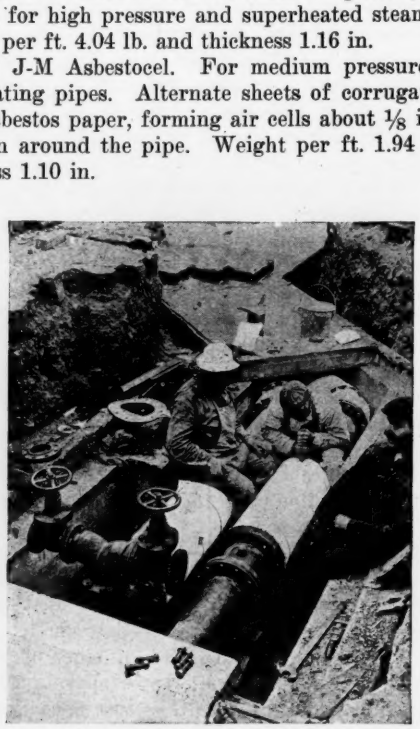


FIG. 3. NONPAREIL HIGH-PRESSURE COVERING ON UNDERGROUND HEATING LINE

17: J-M Air Cell. Corrugated and plain sheets of asbestos paper arranged alternately so as to form air cells about ¼ in. deep, running lengthwise of the pipe. For medium pressure steam and heating pipes. Weight per ft. 1.55 lb. and thickness 1.00 in.

### Insulation for Cold Pipes

Insulation is extremely essential to economical refrigeration, where low temperatures are maintained by the expenditure of energy. An increase in the temperature of the refrigerating medium while flowing through the piping from the machine to the room or tank where it is to be utilized calls for an additional outlay of work.

It is important that insulation for cold pipes should not be readily injured by moisture. One form of insulation which gives satisfaction in some instances is made by soaking hair felt in boiling resin, and applying to the pipe while the resin is still hot and the sheets of felt are easily molded to the shape of the pipe. Heavy twine is employed to fasten the sheets; 2 layers of the covering are applied, and after the resin has cooled and set the twine is removed.

Being thoroughly water-proofed and thus able to prevent the entrance of moisture into the covering, the J-M Brine and Ammonia Built-Up covering is suitable for cold pipe lines. Cold water pipes passing through warm

rooms may cause great damage from sweating, especially in the summer months when the humidity is high. To prevent this action, a special form of insulation, known as J-M Anti-Sweat has been developed, which keeps the warm, moist air from coming in contact with the cold pipe.

Granulated cork molded in a shape similar to the magnesia sectional steam-pipe covering is one of the standard forms of sectional insulation now on the market. In some instances, 2 layers of this are applied so as to break joints, and the whole covering is given a coat of rubber cement, making it virtually air-tight. Large brine mains that are boxed or laid underground can be insulated with a mixture of ground cork and pitch. The pitch is first melted, then cork is mixed with it, and the mixture is then poured over the pipes and well tamped around them.

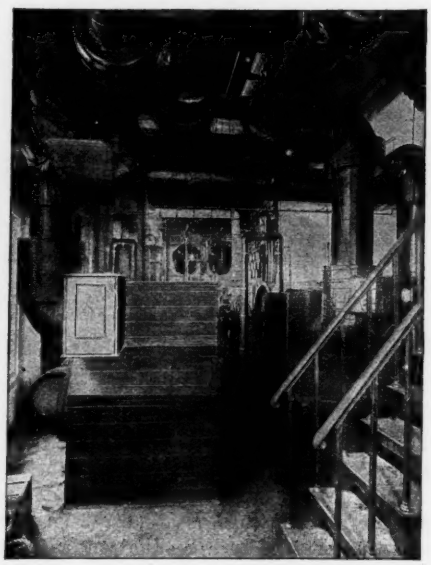


FIG. 4. BRINE LINE AND PUMPS WITH CORK INSULATION

The proper care of insulation covering plays a large part in its effectiveness. If, from any cause, it becomes loose or wet or disconnected, its efficiency is directly affected. It should be thoroughly inspected and repaired every year; the slight cost for this attention will easily be covered by the saving resulting from a greater efficiency.

---

AT A RECENT FIRE in Allentown, Pa., new hose, which was bought as Underwriters' hose, burst on the first trial, the result being that a blaze, which might have been quickly extinguished, gained headway and caused a loss amounting to $7000.

Underwriters' hose is tested by a representative of the National Underwriters' Laboratories to a pressure of 300 lb., and all hose which is of this quality has the Underwriters' Laboratories label on each length.

The lesson is, that in buying fire hose, care should be taken to specify Underwriters' hose, and then see that no length of hose is accepted which does not carry the Underwriters' label, insuring that it has been tested to a safe pressure.

# Supporting and Installation

MEASUREMENT AND LISTING MATERIAL REQUIRED; CUTTING AND THREADING PIPE, MAKING UP OF CONNECTIONS

FREQUENCY of pipe supports is determined more by branch connection requirements and for the prevention of vibration than the weight of the piping itself. The interval between hangers should, however, not exceed 12 ft., except for small pipe, which may be supported on 18-ft. centers.

In vertical runs the risers are anchored only sufficiently to prevent sidewise movement, the weight of the piping in short lines being sustained by the connecting horizontal runs or the branch connections as in Fig. 1. Long and heavy vertical runs may be supported by means of a base elbow, as at A, Fig. 2, resting upon a concrete pier and steadied by guides at frequent intervals.

Medium size vertical runs may be supported as at B, C and D, Fig. 2, the adjustable bracket support shown at D being particularly well adapted where risers run parallel to walls or columns.

Hangers suitable for both light and heavy piping are shown at A to M, Fig. 3. These are generally

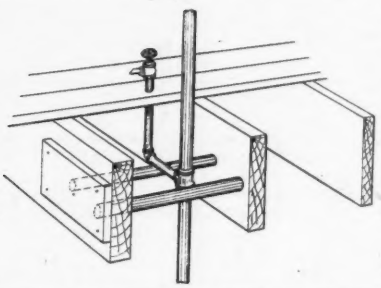


FIG. 1. METHOD OF SUPPORTING RISER IN HEATING SYSTEM

attached to overhead construction, clamps being employed for connecting to I beams, heavy eyebolts or lag screws for wooden beams, or ceilings, while plates or bars are imbedded in reinforced concrete, to which the hangers may be attached. Where hollow tile construction exists the hanger may be suspended as at K. Compensation for expansion and contraction and proper alinement of the pipe line is secured by the use of swing joints, ball-and-socket joints and turnbuckles. A more satisfactory provision for the movement of pipe lines, however, consists of short lengths of piping or cast saddles capable of rolling on some form of center pin, as may be seen by referring to E, I, L, S and T, Fig. 3.

Large and heavy piping, such as steam and exhaust headers, air lines, water mains, etc., when not in trenches, is generally carried on substantial wrought-iron or cast-steel brackets securely bolted to side walls or columns, the pipe resting in a cradle or a rolling saddle, adjustable in both vertical and horizontal directions. When the pipe is subject to considerable buckling, as when carrying superheated steam, a roller bearing resting on top of the pipe and bolted to the bracket through tie rods and springs, is frequently employed.

Floor stands, or pillars (N, O and P, Fig. 3), adjustable as to height, are generally provided with Y-shaped brackets, although semi-circular brackets or cradles with

holding-down straps conforming to the curvature of the pipe are preferable.

TABLE I. ALLOWANCES TO BE MADE IN PIPE LENGTHS FOR FLANGED FITTINGS

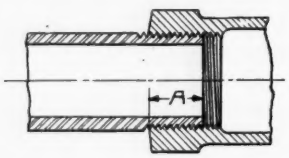
| Subtract for | 1-1/4 | 1-1/2 | 2 | 2-1/2 | 3 | 3-1/2 | 4 | 4-1/2 | 5 | 6 | 7 | 8 | 9 | 10 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Flanged - Std. | 4 | 4-1/2 | 5 | 6 | 6 | 7 | 8 | 8 | 9 | 10 | 11 | 11 | 12 | 13 | 15 |
| " Ex. Hy. | 5 | 5-1/2 | 6 | 7 | 7 | 8 | 9 | 9 | 10 | 11 | 12 | 12 | 13 | 14 | 16 |

Pipe lines crossing alleys, streets, yards or courts where the use of hangers or pillars is impracticable, require some exceptional form of suspension or bracing, as in Fig. 4.

## Installation

Pipe lines should be kept as short as possible, the number of joints reduced to a minimum, and in the case of steam piping ample provision made for drainage and

TABLE II. LENGTH OF PIPE THREAD SCREWED INTO FITTINGS TO PROVIDE A TIGHT JOINT




| Pipe Size Inches | Dimension A Inches | Pipe Size Inches | Dimension A Inches |
|---|---|---|---|
| 1/8 | 1/4 | 3-1/2 | 1-1/16 |
| 1/4 | 3/8 | 4 | 1-1/16 |
| 3/8 | 3/8 | 4-1/2 | 1-1/8 |
| 1/2 | 1/2 | 5 | 1-3/16 |
| 3/4 | 1/2 | 6 | 1-1/4 |
| 1 | 9/16 | 7 | 1-1/4 |
| 1-1/4 | 5/8 | 8 | 1-5/16 |
| 1-1/2 | 5/8 | 9 | 1-3/8 |
| 2 | 11/16 | 10 | 1-1/2 |
| 2-1/2 | 15/16 | 12 | 1-5/8 |
| 3 | 1 | | |

Dimensions given do not allow for variation in tapping or threading.

CRANE CO.

expansion. Valves should be so arranged as to permit cutting out of faulty sections without service interruption and all covering employed should be applied in a neat and durable manner and so as not to interfere with repairs.

While roller-bearing saddles allow considerable freedom of pipe movement, this type of support increases the tendency of the pipe to vibrate. Many times, therefore, a free-sliding support in which the pipe may come and go and at the same time place a damper on any tendency to vibrate is preferable.

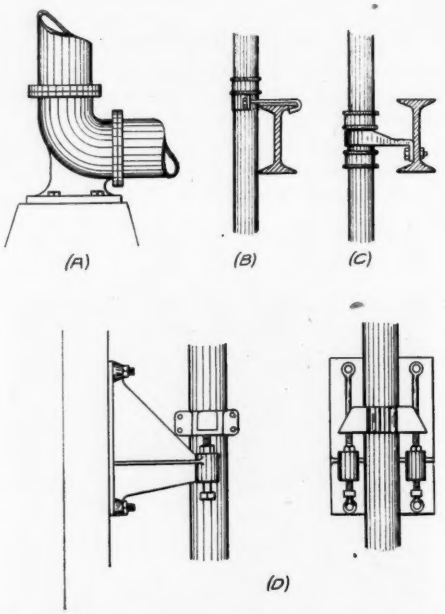



FIG. 2. METHOD OF SUPPORTING MEDIUM-WEIGHT AND HEAVY RISERS

In taking measurements for pipe lines, it is customary first to obtain the distance between the centers of the fittings to be connected and then make the necessary allowance for these fittings as at (A), Fig. 5, where X represents the distance between the center of the elbow and that of the tee, while Y is the actual required length. For flanged fittings, make allowance as indicated in Table I. For screw fittings, subtract from X twice the distance from center to face; then add twice the distance pipe is to enter fittings as indicated in

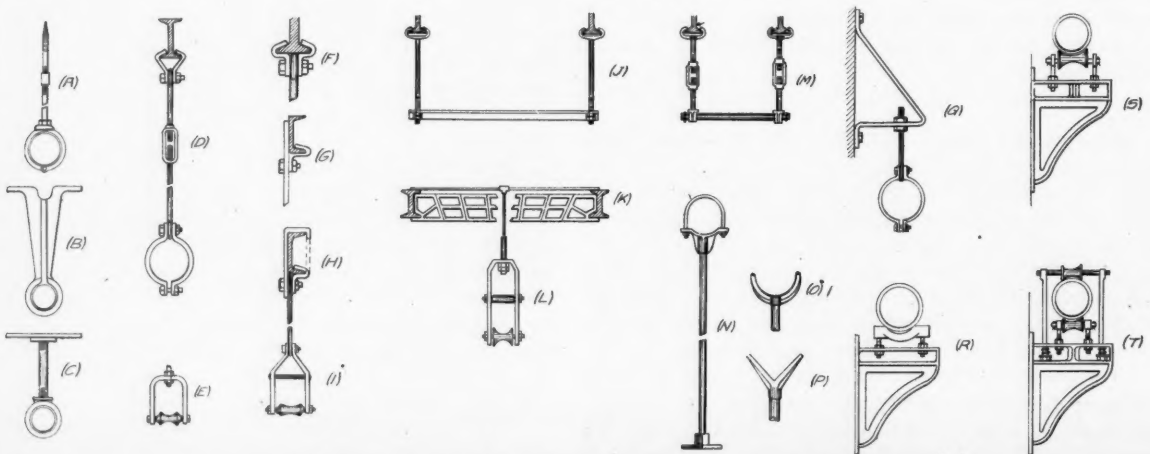



FIG. 3. VARIOUS TYPES OF COMMONLY-EMPLOYED HANGERS, PILLARS AND BRACKETS

Table II. Where specifications call for a simple U bend, the total length of stock required may be determined by adding the sum of the lengths of the 2 arms to the length of the curved portion obtained by multiplying the radius of curvature by 3.1416, all measurements being taken along the center line of the pipe.

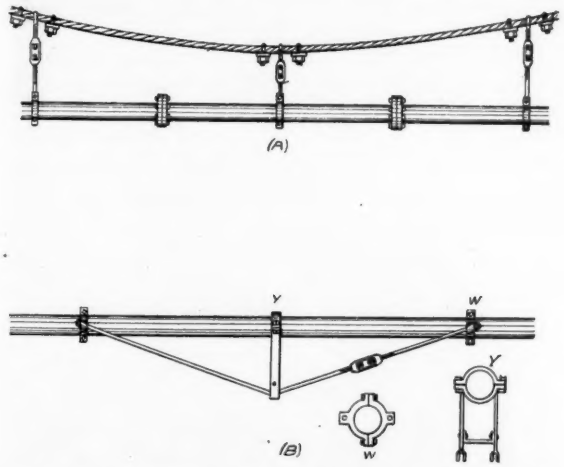



FIG. 4. CABLE SUSPENSION AND BRACING FOR LONG PIPE LINES

To estimate the length of an irregular curved line or offset make an exact scale drawing of the proposed work, measure along the center line by means of a tape line or measuring wheel and multiply by the length of scale employed.

When measuring offsets of 45 deg., as at B, Fig. 5, distance Y may be obtained by direct measurement along the axis of try pieces t, t, or if this is inconvenient by

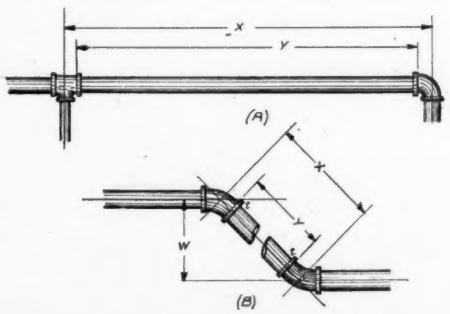



FIG. 5. DIMENSIONS TO BE CONSIDERED WHEN TAKING MEASUREMENTS FOR PIPE LINES

multiplying W, the exact distance between centers of the 2 parallel pipe lines to be joined, by the secant of 45 deg., or 1.4142, and subtracting from the result thus obtained 2 times the distance between the center and the inner end of the threaded portion of the fittings. multiplying W, the exact distance between centers of the For 60, 30 and 22½-deg. fittings, multiply distance W by 1.15, 2.00 and 2.61, respectively, to obtain X.

In the majority of cases and especially on small jobs it is up to the man who is to install the new piping to determine the quantity and sizes of piping and fittings required. This may best be done by making a sketch (preferably to some convenient scale) of the proposed layout and from that determine the necessary number and size of fittings and lengths of piping. Let us, for example, assume the engineer of a power plant about to order the necessary piping and fittings with which to connect a newly-installed 200-hp. horizontal return-tubular boiler to the existing steam header, feed lines and blowoff mains. With information gained from the boiler manufacturer's prints, from supplementary sketches prepared by himself and from measurements taken in connection with his present equipment he would properly fill out a requisition as in Fig. 6.

### Cutting, Threading and Making Up

Piping up to 2 in. in diameter may be cut by means of a single wheel cutter, while larger sizes and that in trenches or otherwise where impossible to give the cutter arm a full turn, should be cut with a 3-wheel cutter. All sizes above 6 in. are usually cut with a hack saw or cutting machine, the oxy-acetylene flame or the electric arc.

ORIGINAL
Form 8-19

REQUISITION
FOR DEPARTMENT SUPPLIES

Req No 471 Please furnish the following for Power Plant Dept

| ✓ | | Quan | |
|---|---|---|---|
| | | 1 | 16 ft (length) single offset quarter bend of 4 in. lap welded steel pipe as per att. sketch — fitted with walker flanges having 8½ in. bolt holes on 7½ in. circle. |
| | | 1 | 18 ft length of 2½ in. St. I. pipe for blowoff |
| | | 4 | 18 ft lengths of 2 in. St. I. pipe for feed line |
| | | 4 | 18 ft length of ¾ in. St. I. pipe for water column & drain and gage connections. |
| | | 1 | 4 in. Golden Anderson Non Return Stop Valve |
| | | 1 | 2½ in Everlasting Blowoff Valve |
| | | 1 | 2½ in Lunkenheimer Extra angle blowoff valve |
| | | 2 | 2 in Lunkenheimer brass globe valve |
| | | 1 | ½ in Lunkenheimer brass globe valve |
| | | 1 | 2½ in. extra heavy Tee |
| | | 1 | 2 in. " " " |
| | | 3 | 2 in. " " elbs |
| | | 2 | 2 in. Mark Unions |
| | | 2 | ¾ in extra heavy tees |
| | | 5 | ¾ in. " " elbs |
| | | 2 | ¾ in. Mark Unions |

Chas Sullivan Ch. Eng.

FIG. 6. SAMPLE FORM OF REQUISITION FOR USE WHEN ORDERING PIPING AND FITTINGS

In cutting and threading, care should be taken first that there is no reduction of the internal diameter of the pipe, and second that the thread is so cut as to give a proper amount of make-up. Any burr made by the cutter on the inside of the pipe should be carefully removed and the end of the pipe examined for cracks or splits started in the cutting process. The length of the perfect thread should correspond with that shown in the table of pipe sizes, but should not exceed such value in order to avoid the joint leaking or the pipe entering the fitting too far and throwing it out of alinement, or possibly in the case of a coupling or tee causing interference between pipe ends.

In making up a pipe joint, it should be screwed securely into place but not forced more than necessary in order to avoid producing a strain on the fittings and the likelihood of cracking them when steam is turned on.

In making up the final joint, a union, either of the screw or flange form is to be preferred to a right-and-left coupling, although, if absolutely necessary to use such a coupling, care should be taken to have the fitting make up onto both ends of the pipe so as to give a tight joint.

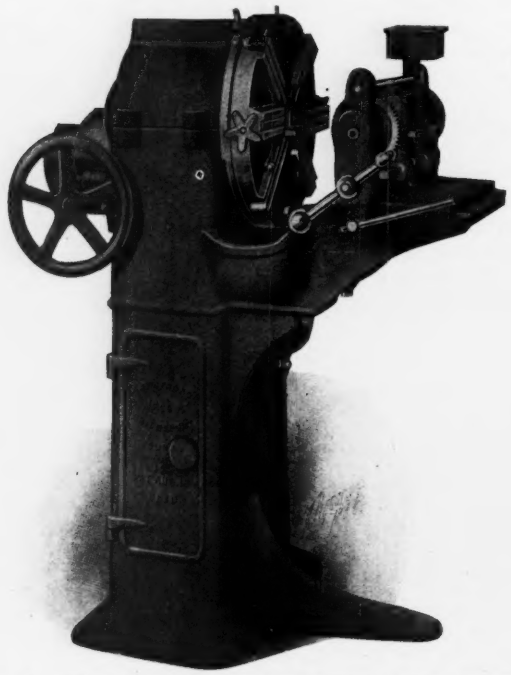


FIG. 7. THE ARMSTRONG POWER-DRIVEN PIPE MACHINE

For steam-tight screw joints, many engineers use a mixture of cylinder oil and graphite, although the following mixture suitable for both steam and water pipes is recommended: Ten pounds fine yellow ocher; 4 lb. ground litharge; 4 lb. whiting and ½ lb. hemp cut up fine. Mix thoroughly with linseed oil to about the consistency of putty.

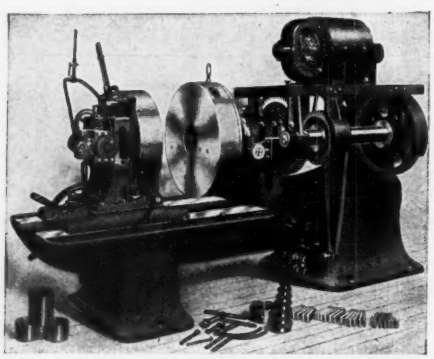


FIG. 8. THE E. C. & B. MOTOR-DRIVEN PIPE MACHINE

For ammonia pipe joints use a mixture of litharge and glycerine. This filler sets so quickly, however, that only enough for one joint should be mixed at a time, and when the joint is once made it should not be disturbed as the filler is useless having once set.

### Pipe-Cutting and Threading Machines

Pipe-cutting and threading machines, especially those of large size, bear a close resemblance to lathes. They may be equipped for hand, belt or direct motor drive, and may be of the stationary vise and revolving die head, or revolving spindle and stationary die head type, the former being preferable for all heavy work. Motion is imparted to the die head, as in lathes, through the medium of a series of reduction gears.

The Armstrong No. 1½ power pipe machine, as shown in Fig. 7, consists of a revolving die head cast integral with a hollow spindle and driven by an enclosed train of gears and a bracket supporting an adjustable centering open vise, the whole being mounted on a cabi-

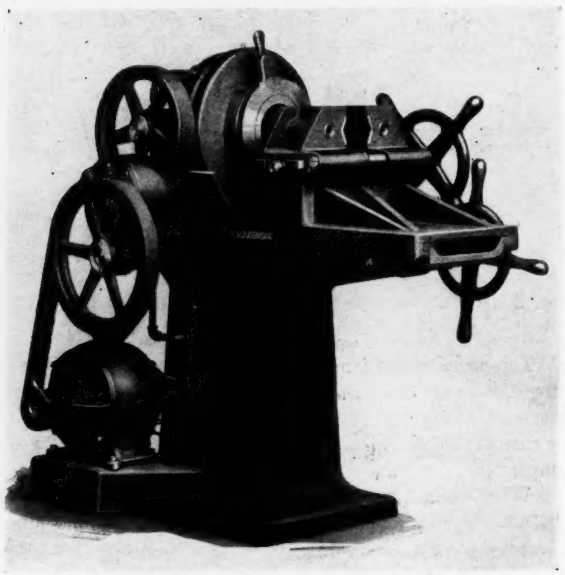


FIG. 9. THE OSTER MOTOR DRIVEN PIPE MACHINE

net type of base. The die head is fitted with clutches similar to those used on lathes, the dies being adjusted by means of 2 star wheels operating the tool carrier feed screws.

In the No. 3½ E. C. & B. motor-driven pipe machine of the Crane Co., the gripping chuck is designed to allow gripping or releasing the pipe by the movement of a lever without stopping the machine. The 4 jaws this chuck contains have 8 removable roller contact teeth and are adjusted by an internal cam operated by a worm and gear. The rear end of the spindle contains an independent 3-jaw chuck for centering or gripping long pipes.

Carried by the movable die head are adjustable expanding dies in sets of 6, pipe-centering guides and an air-cutting attachment operated by a pressure device controlled by a cock, the opening and closing of which governs the working of the 2 cutting-off tolls. Where air is not available, a hand cutting attachment may be used instead. Oil is supplied to the dies by means of a direct driven rotary pump.

An adjustable sliding vise of the open type is used to hold the pipe in the Oster No. 304-B motor-driven pipe machine. A single lever fastened to the die cam is employed in releasing the dies, for resetting when mak-

ing duplicate threads, for changing from one size to another and in setting to graduation on the face plate. The head of the die being 1/16 in. higher than the front, the dies are prevented entering the head farther than necessary.

Cutting off is accomplished by means of a cutter set into the end of the sleeve and operated automatically

FIG. 10. FORBES MOTOR-DRIVEN PIPE CUTTING AND THREADING MACHINE

by a pawl attached to the frame of the machine. A ratchet attachment automatically regulates the feed of the cutter.

Oil is pumped from a large reservoir into a smaller one in the die head from where it is distributed in jets to all sides of the pipe.

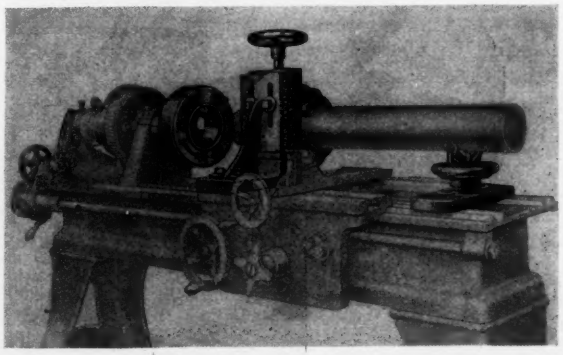


FIG. 11. TYPICAL PATENT PIPE THREADING ATTACHMENT FOR LATHES

Adjustment of dies in the Forbes motor-driven pipe cutting and threading machine, Fig. 10, is by means of a specially designed head, clamping being accomplished by the movement of a lever on top of the die head. This, which is of the stationary type, is driven by a motor concealed in the cabinet base, through the medium of protected triple compound spur gears. Variable speed may be obtained and the machine started and stopped by a shift lever.

The vise is self centering; a direct-connected shaft-driven pump delivers a continuous stream of oil to the cut.

For shops not equipped with regulation pipe cutting and threading machinery, various patent pipe-threading attachment for lathes have been developed. These consist of a die-carrying head, attached to the spindle like a chuck, an adjustable self-centering vise attached to the carriage, and an adjustable pipe rest, attached to the bed of the lathe to support long lengths of pipe. The pipe is held securely by the vise on the carriage and fed to the revolving dies by moving the carriage by hand or automatically by the lead screw of the lathe, set to the number of threads corresponding to the standard of thread to be cut.

### Bending Pipe

Commonly-employed sizes of brass and copper pipes and iron pipes 1 in. and less in diameter may be bent cold in the following manner, care being taken when doing so to have the seam on the inner curve: With a brace and bit bore a hole about ½ in. larger in diameter than the pipe to be bent, in a solid well-supported soft

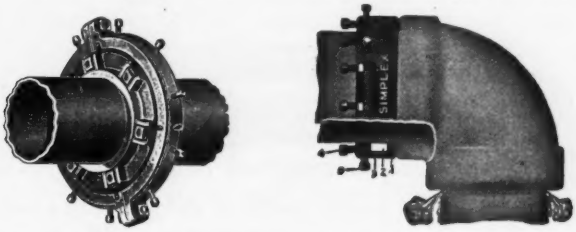



FIG. 12. THE MODEL FLANGE CLAMP AS APPLIED TO PIPE
FIG. 13. THE SIMPLEX PIPE-JOINT CLAMP

pine timber. Insert the pipe to the point at which the bend is desired and make the bend by pulling slowly to one side, moving the pipe in and out a little after each pull.

If any considerable bend is required, a form should be made having the curvature to which it is desired to bend the pipe, and while one end of it is held fast, the pipe should be bent around this form. If the curvature is sharp, fill the pipe with perfectly dry sand and heat it to a red heat before bending.

### Colors for Piping

A scheme for the purpose of ready identification of piping systems is that embodied in the A. S. M. E. Report of Committee on Identification of Power-House Piping. This committee suggests that colors shall be used on valves, flanges and fittings only, the piping proper to be painted to conform to the color scheme of the room. Its recommendations are as follows:

| | |
|---|---|
| Steam divison | a—High pressure—white. |
| | b—Exhaust system—buff. |
| Water division | c—Fresh water, low pressure—blue. |
| | d—Fresh water, high pressure boiler feed lines—blue and white. |
| | e—Salt water piping—green. |
| Oil division | f—Delivery and discharge—brass or bronze yellow. |
| Pneumatic division | g—All pipes—gray. |

Gas division.....h—City lighting service—aluminum.
i—Gas engine service—black, red flanges.

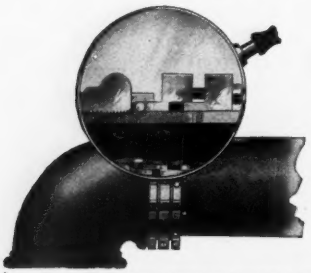


FIG. 14. THE CLIMAX STEAM-JOINT CLAMP

Fuel oil division.....j—All piping—black.
Refrigerating system....k—White and green stripes alternately on flanges and fittings, body of pipe being black.

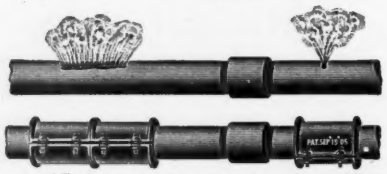


FIG. 15. THE EMERGENCY PIPE CLAMP

Electric lines and feeders.l—Black and red stripes alternately on flanges and fittings, body of pipe being black.

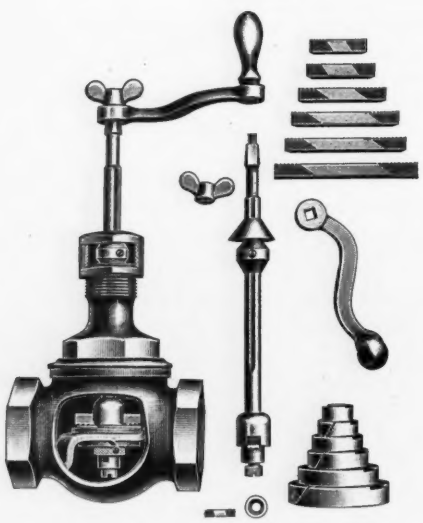


FIG. 16. THE NOLD VALVE RESEATING TOOL

## Costs

PIPING COSTS like those of any other equipment entering the power plant vary, depending upon the current market prices of the materials and labor employed in its manufacture. Approximate labor costs expressed as a percentage of material costs as obtained from the records of a widely experienced engineer and contractor, and covering a period of 4 yr. are shown below.

| Material Cost, Dollars | Labor Cost, Per Cent Material Cost |
|---|---|
| 200 and under | 40 |
| 200 to 500 | 40 (Average) |
| 500 to 1000 | 45 (Average) |
| 1000 to 2000 | 25 (Average) |
| 2000 to 5000 | 20 to 30 |
| 5000 to 10,000 | 40 (Average) |
| 10,000 to 25,000 | 20 to 35 |

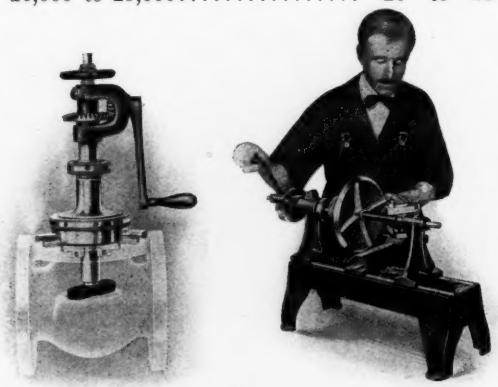


FIG. 17. DEXTER VALVE RESEATING AND DISC REFACING MACHINE

## Emergency Repairs

FLANGE LEAKS due to the blowing out of packing, may be readily stopped by means of the Model Flange Clamp, which consists of an outer brass ring made in 2 sections fitted with compression screws, an inner or compression ring in 4 sections with a lug on each section fitting into a slot in the outer ring and a strip of packing to encircle the entire flange. The method of application is shown in Fig. 12.

FIG. 18. SKINNER VALVE RESEATING TOOL

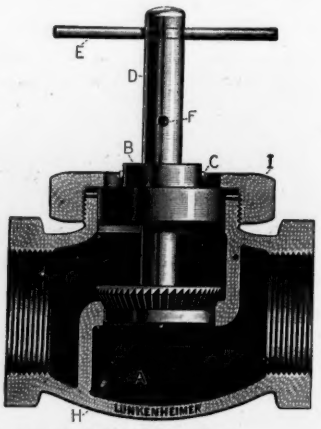



FIG. 19. THE LUNKENHEIMER RESEATER

Leaks due to imperfect fit between flange and pipe can be stopped by applying a clamp such as shown in Figs. 13 and 14. The former, the Simplex pipe-joint clamp, is made up of an outside ring (3) bolted around the pipe and secured to it by means of set screws (5), and an inside ring (2) which by means of adjusting screws forces a ring of square packing (1) against the leaky joint. The other, the Climax steam-joint clamp consists of a fixed ring held to the pipe by set screws and

a loose ring which compresses the packing within a container ring. This is accomplished by means of adjusting screws acting against the loose ring, although in some sizes the fixed and loose rings are joined by screw threads, the packing being compressed by turning the loose ring with a spanner provided for the purpose.

When rust holes or split seams are the cause of leaks within the body of the pipe a strip of sheet packing held in place over the faulty section by means of the Emergency pipe clamp, as in Fig. 15 will be found to eliminate the trouble.

### Valve Reseating Machine

For valves up to 4 in., these machines are generally of portable form and consist of a cutter with attachments for turning and a guide for steadying the tool. The cutter may be circular or flat; the spindle may be guided by means of the valve bonnet or by some form of adjustable chuck attached to the valve body after the bonnet has been removed.

If so desired, the spindle to which the cutting tool is attached may for convenience be turned by a brace or breast drill.

# Water Piping

### Velocity, Capacity and Friction Head

IN DETERMINING THE SIZE of piping for a water line, the problem comes, usually, to determine the size of pipe needed to carry a given amount of water with a reasonable loss in head due to friction, or to determine what loss in head will be encountered with a given size of pipe and a given amount of water flowing, or to determine how much water will pass through a given pipe with a reasonable loss in head from friction.

The factors that enter into this problem are the diameter and length of pipe, condition of the pipe as to the internal surfaces, and velocity with which the water must flow. Various rules and formulas have been devised to embody the results of experiment; but those which, on the whole, are most convenient and come nearest to representing the results are the ones proposed by Prof. Schoder of Cornell University. For new and clean pipes having smooth surfaces, his equation becomes, the loss of head in feet per 1000 ft. of pipe $= 8.49V^{1.86} \div d^{1.25}$, and for old pipes whose surfaces have become roughened by corrosion or accumulation of foreign matter, also for spiral riveted pipes, this changes as follows: head lost $= 11.17V^{1.96} \div d^{1.25}$. In both equations, V represents the velocity in feet per second, and D, the diameter of the pipe in inches. The equations give the loss in head for each 1000 ft. length of pipe.

Since this equation is somewhat difficult of solution, particularly when it is desired to find the diameter of pipe for a given volume or weight of water to be passed, and for a given loss of head by friction, the results have been embodied in the chart herewith, Fig. 1, from which readings can be taken direct. The curves on the left-hand side of the chart give the amount of water in pounds, or cubic feet, or gallons per minute, for any size pipe, at any velocity between 1 and 15 ft. per second, which is the range usually permitted. The velocity per minute will, of course, be 60 times the velocity per second.

The chart on the right gives the means of determining, by a straight edge, any one of the 3 factors—amount of water per minute, loss of head per 1000 ft. of pipe, or diameter of pipe—when the other 2 factors are known. As, for instance, if it is desired to know the loss in head for a 4-in. pipe carrying 20 cu. ft. per minute, the straight edge is passed through 20 on the cubic feet per minute scale, and through 4 on the pipe diameter scale, and where it crosses the loss of head scale will give the desired value, 18 ft. for new pipe.

The right-hand pipe diameter scale is for new and smooth pipes, the left-hand diameter scale for old or rough pipes. These values apply to straight lengths of pipe. Where fittings or valves are introduced, extra loss of head will result. The simplest way to bring in this loss is by introducing the equivalent length of straight pipe, which from experiments is practically as follows:

ADDED LOSS OF HEAD IN FITTINGS AND VALVES

| Kind— | Added Length in Pipe Diameters |
|---|---|
| Bends, radius ± pipe diameter | 20 |
| Bends, radius ± 2 to 8 diameter | 10 |
| Elbow short turn 90 deg | 30 |
| Elbow short turn 45 deg | 6 |
| Tees short turn 90 deg | 60 |
| Gate valves | 6 |
| Globe valves | 60 |
| Angle valves | 90 |

### Suction Lines

The distance that water can be raised by suction depends on the vacuum which can be formed at the pump, the temperature of the water, and the friction in the suction line. There will always be a certain amount of leakage through joints, and the valves in the pump will not hold absolutely tight, so that it is found that the following are about the practical lifts for different barometric pressures, with pump and suction line in good condition:

| Barometer pressure, in. mercury | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 22 |
|---|---|---|---|---|---|---|---|---|
| Practical lift, ft. | 24 | 23 | 22.5 | 21.5 | 21 | 20 | 19 | 17.5 |

From this lift must be subtracted the loss of head in the pipe due to friction, and the loss due to fittings and valves, hence the suction line should be short and direct, of full pump connection size or larger, with as few fittings as possible and gate valves to give satisfactory operation, and it is desirable to limit the velocity in a suction pipe to 150 ft. per minute, or about 2.5 ft. per second, or for hot water to 75 ft. a minute.

Where a long suction line or a maximum lift is necessary, install a foot valve at the inlet end of the suction pipe, to hold the water in the pipe while the pump is idle. For short lines and moderate lifts, omit the foot valve, as its friction will be equivalent to a loss of 1 ft. in the possible lift.

For suction lines laid underground use cast-iron to avoid corrosion, and with flange joints and gaskets having provision for supporting the line so that there will be no sagging. For a long line, expansion must be provided for.

Connection of several suction lines to a single main tends to uneven action of the pumps, but where this is unavoidable a suction chamber at the inlet to each pump is a good investment, and should be located as shown in Fig. 2. If several pumps are on one main connected close together, it is possible to use a single air chamber for the entire line, and this should be arranged so that the flow of water into and out of the air chamber, to take up the variations in pressure, will be direct.

In starting up a pump which has been idle for some time, there will almost always be air in the suction line, and pumping out may become a tedious process. To avoid this, provision should be made to discharge the air from between the valve decks by short pipe and valve located at about ¼ in. below the discharge valve deck; where there is a long lift, and for centrifugal pumps, provision should be made for priming the pump with water before starting, and a foot valve should be used on the inlet pipe. If water cannot be supplied for priming, the air may be exhausted from the pump by a steam ejector connected as shown in Fig. 3.

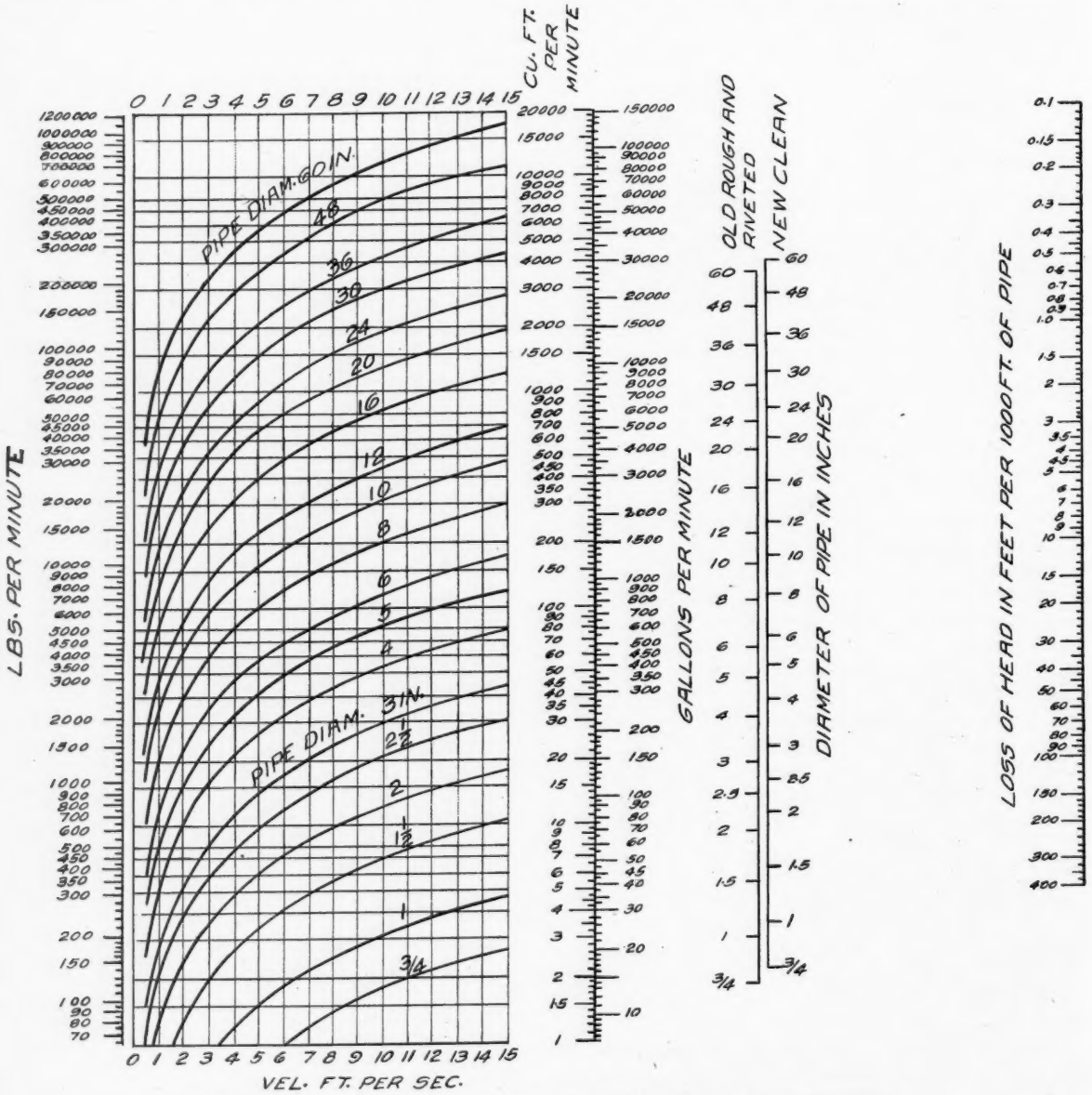

LBS. PER MINUTE
CU. FT. PER MINUTE
GALLONS PER MINUTE
VEL. FT. PER SEC.
PIPE DIAM. IN.
OLD ROUGH AND RIVETED
NEW CLEAN
DIAMETER OF PIPE IN INCHES
LOSS OF HEAD IN FEET PER 1000 FT. OF PIPE

FIG. 1. CHART OF FLOW OF WATER IN PIPES AND LOSS OF HEAD BY FRICTION

For handling hot water, it is necessary to have the suction on the lift less than the pressure at which the water will evaporate. The lifts as given in the preceding table are for water at 60 deg. or less. Where water is above this temperature, the possible lift is less, as shown in the left-hand side of the following table, the barometric pressure being assumed as 30 in. of mercury, and 50 ft. per minute piston speed of the pump.

SUCTION LIFT AND HEAD FOR HOT WATER

| Temperature Deg. F. | Possible Lift Ft. | Temperature Deg. F. | Head on Inlet, Ft. |
|---|---|---|---|
| 70 | 20 | 160 | 1 |
| 80 | 17 | 170 | 3 |
| 90 | 15 | 180 | 5 |
| 100 | 13 | 190 | 7 |
| 120 | 8.5 | 200 | 9 |
| 140 | 4 | 210 | 11 |

With a temperature over 150 deg., it is practically impossible to raise water by suction, and the water should come to the pump inlet under a pressure head according to the right-hand side of the table, although

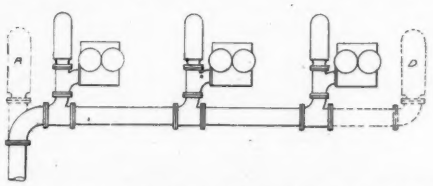


FIG. 2. CONNECTION FOR SUCTION AIR CHAMBER

for extreme cases, somewhat less values of head may work satisfactorily. For high speed pumps, the possible lift will be somewhat less, and the head needed for water above 160 deg. will be greater, in order to avoid steam binding in the suction line and pump cylinder.

If a long suction line is necessary for hot water, it

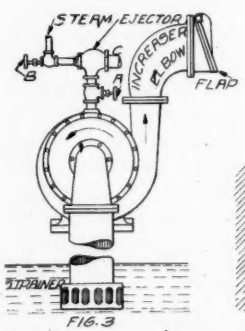



FIG. 3

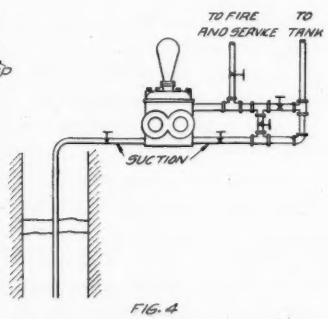



FIG. 4

FIG. 3. STEAM EJECTOR FOR STARTING PUMP SUCTION
FIG. 4. CONNECTION FOR SUCTION FROM WELL AND STORAGE TANK

will be helpful to provide a stand pipe near the inlet to the pump, making this of sufficient height to give a head direct at the pump equivalent to the values as shown in the table.

In arranging suction from a hot well, the suction inlet should be considerably below the upper surface of the water, to avoid drawing in oil, but above the end of the condenser tail pipe, and preferably in a separate compartment, to avoid possibility of pumping out the water seal.

If the water is badly impregnated with oil, it is well to put an excelsior box or other filter in the pipe between hot well and pump, making this of a size so that there will be a cubic foot of excelsior to each 100 boiler horsepower, and changing the excelsior each week.

An emergency connection should be made to some other source of feed than the hot well, in order to avoid shutting down the plant if the hot well is out of commission. Where this emergency source is the city mains, so that water comes under pressure to the suction, an air chamber should be used in that branch to avoid water hammer as the pump reverses, and a foot valve should be installed at the low-pressure intake to prevent city water backing to the hot well.

The installation of a gage on the suction line near the pump is useful, as any variation in this suction reading will show faults in the suction line. If the city water supply as well as low-pressure are used for suction, the gage must be of the compound type, which will register either vacuum or pressure.

In certain arrangements, it is necessary to be able to take the suction either from a well or from an emergency tank, particularly where a pump is used for fire service as well as general service, and in this case, the arrangement of valves and piping must be carefully worked out. One possible arrangement shown by Morris is as indicated by the illustration, Fig. 4.

# Feed Lines

EXTRA HEAVY material should in common practice be employed on boiler feed pipes, and the size is ordinarily chosen for a velocity of from 300 to 400 ft. a minute. To secure a uniform standard, the flanges should be of the same type as that of the main steam piping, and in order to supply any boiler in case of emergency, the main line should be paid out with either a double-header or ring system; sufficient valves being inserted to cut out defective sections readily.

In Fig. 1 is shown a feed-water piping diagram for a condensing plant. With this arrangement the cold water and condensate from the discharge pumps are turned into a hot-well, from which the feed pumps take their supply. The pumps are in duplicate, each being of sufficient capacity to do the entire work. The injector is placed on a branch of the cold water line and all equipment is by-passed as indicated. Both primary and secondary heaters are provided, the first being placed in the main exhaust line from the engines and the second taking the pump exhaust as shown.

### Pump to Main

EACH BRANCH from a boiler feed pump should be provided with a stop valve of the gate type so that the pump may be disconnected from the main. Between this valve and the pump there should be a check valve and a pressure relief valve. The relief valve, which is ordinarily about ½ the size of the discharge pipe, is not placed between the pump stop valve and the feed main with the idea of protecting the main, but to protect the pump, as it is not an unusual occurrence for an operator to start a pump with the discharge valve closed.

Feed water which is to be heated by the flue gases should be introduced at the bottom of the economizer and discharged from the top, with the flow of the water in a direction opposite to that of the gases. If, however, the installation is of such a nature as to make it necessary both to receive and discharge the water at the top of the economizer, the upper manifold should be blanked so that the water will not take a direct path from the inlet to the outlet.

When a feed-water heater of the steam-tube type is employed, the water should be introduced into the heater at a low point and discharged at a high point with a blowoff at the extreme top of the heater to remove floating impurities. The heater should be bypassed so that it can be cut out and the feed water go directly to the boilers.

Whenever an economizer or closed heater is employed, a relief valve should be placed between the inlet and outlet water valves to protect the apparatus should heat be turned on when the valves are closed. Relief valves used for this purpose need not be over ¾ in. in size.

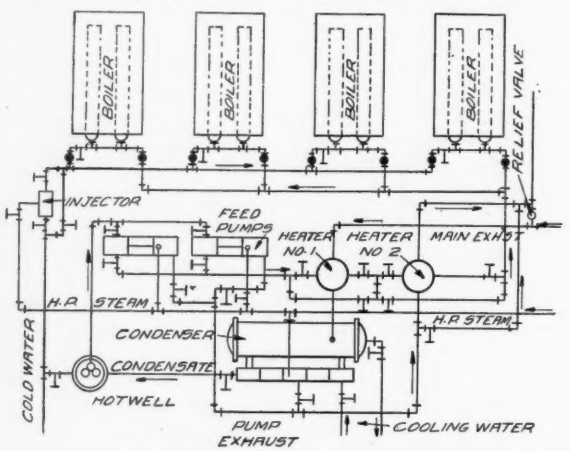



FIG. 1. FEED PIPE ARRANGEMENT FOR CONDENSING PLANT

Injectors afford a means for feeding warm water when for any reason the heater may be out of service. Feeding boilers with cold water may cause damage much in excess of the cost of an injector. It is connected with the same suction, discharge and steam lines as a pump, using a stop valve for each of the 3 branches.

### Pump Piping

In arranging for feed pumps, two will be required in any case, and while one is used for boiler feeding, the other can be employed for filling boilers, operating tube cleaners, etc. In addition to these 2 lines of water service it is necessary to have a low pressure system operating on about 25 lb. pressure, which can be used for wetting down ashes, for plumbing fixtures, washing floors, for the makeup water, and other similar services. Supplementing this house service, there should be a fire service system, the pump for which should be able to maintain 100 lb. pressure running at full speed. These 4 services must be available at all times, although it is not necessary or desirable to keep the fire service pressure on all the time.

Various combinations of pumping conditions, with different arrangements of economizers, heater and meters necessitate a careful study before a reliable and flexible piping system for the pumps can be decided upon. Figure 2 shows a detailed arrangement which applies well to some systems with an economizer installation. This plan provides for the following requirements:

1. Any part of the feed system may be shut off without reducing the capacity more than one-fourth, for 4 units.
2. Hot-well water may be fed to the economizers when the heater is off.
3. The boilers with economizers off may take their feed from other economizers which are in operation.
4. An abundance of feed reserve is provided.

### Injector Piping

Connections for an injector are shown in Fig. 3. Steam pipe D should always be the same size as the injector connections, and must be connected to the boiler at the highest possible point, and independently of other pipe in order to insure best results. This pipe should be blown out with steam before connecting the injector.

The water supply pipe should be as large as the injector connections, and where the lift is over 10 ft., it should be one or 2 sizes larger, reducing to injector size as near the injector as possible. In this line the valve H

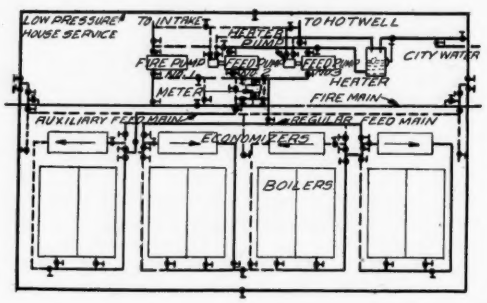



FIG. 2. FEED PIPE SYSTEM FOR ECONOMIZER INSTALLATION

should be a globe valve. On a long lift a foot valve should be placed on the lower end of the suction pipe. Without a foot valve, every time the injector is started, all air must be exhausted from the suction pipe before water can reach the injector, and considerable steam is wasted. With a foot valve, the water is held in the pipe when the injector is stopped.

When water is delivered from an overhead tank or from city water mains, it frequently happens that a heavy pressure exists, and in this instance, to facilitate starting on low steam, some prefer to use 2 globe valves, H and M, in the water supply line. The valve H, placed as near the injector as possible, regulates the water supply, while valve M placed several feet away is employed to reduce the pressure. In the discharge line there should be a check valve and a stop valve, as shown by F and G.

To start the injector, the valve D in the steam line is opened full, and then opening the valve H in the water supply line, with which the amount of water delivered to the boiler can be regulated. When this valve has once been regulated properly, only the steam valve will be used to start and stop the injector, unless the steam pressure carried has altered to a great extent.

Branch pipes to boilers are generally supplied by the

boiler manufacturer. These pipes are, in America, made of extra heavy brass, while in Europe copper is frequently employed. The practice of using brass and copper is due to their ability to withstand more readily such shocks as are received from the pumps, or from shutting of valves, and to freedom from corrosion.

Check and hand valves should be placed in each branch line, so that the water cannot return from the boiler to the feed line should the boiler pressure rise above that in the feed main.

Various methods of placing the valves in the branch lines to the individual boilers of a battery are illustrated in Fig. 4, in which A is a stop valve, B a check valve and C a regulating valve.

Beginning at the left, No. 1 shows the most approved arrangement where the boilers are operated continuously and the regulating valve is subjected to hard usage. With

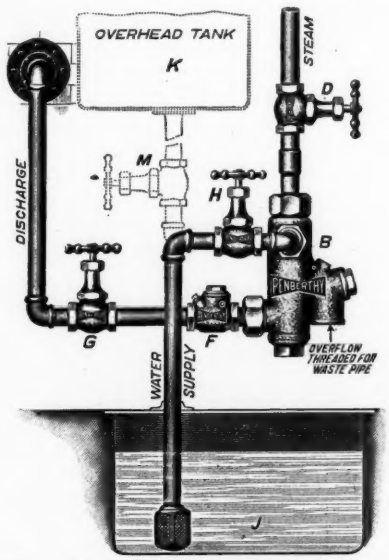



FIG. 3. PIPING CONNECTIONS FOR INJECTOR

this arrangement, the stop valves are left wide open, except in case of repairs to the check or regulating valve, and are, therefore, free from wear. In arrangements Nos. 2 and 3, which are employed in common practice, one stop valve has been omitted and the regulating valve is made to serve as a stop valve in case of repairs to the check valve. In heating work, the stop and the regulating valves are usually combined as in No. 4, making it necessary to shut off the pressure in the feed main in case of repairs to the check valve. This arrangement should not be adopted in power work or in large and important heating plants.

Wherever possible, all frequently used valves in the feed line should be accessible from the boiler-room floor, or from a platform at the engine-room level, or extension stems may be used as shown in the connection of boiler No. 2, Fig. 4.

### Feed Line Discharge

Feed water should enter the boiler at a point considerably below the water line in order to prevent steam from entering any portion of the feed branch and causing water hammer when the feed valve is again opened. In order to minimize the expansion and contraction strains, it is advisable not to allow the feed water to come in contact with the boiler until it has been heated to the temperature of the water in the boiler.

For return tubular boilers, the following method of feeding is recommended by the Hartford Steam Boiler Inspection and Insurance Co. The feed pipe enters the boiler through the front head just above the top row of tubes, and about 3 in. from the shell and extends to within a foot of the back head, at which point it crosses over to the other side of the boiler. It then passes down between the tubes and the boiler shell and discharges below the lowest row of tubes toward the axis of the boiler. If the water carries much lime or magnesia, however, it is best to shorten this internal arrangement.

An arrangement for feeding a water-tube boiler is shown in Fig. 5, in which the internal feed-water tube discharges into the coldest part of the boiler. The nozzle attached to the drum has a blind flange which closes the end opening, and the feed branch opening is at the side of the nozzle. As the feed-water tube is the same size as the boiler tubes, it may be cleared of scale at the same time.

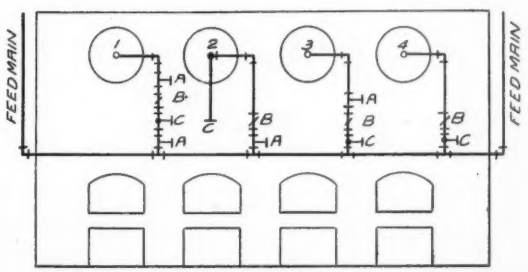



FIG. 4. TYPICAL ARRANGEMENT FOR BRANCH FEED LINES

In the vertical water-tube boiler, such as the Wickes, the feed line enters in the rear of the upper drum, the feed water then descends through the rear tubes, which act as a heater, and after passing through the bottom drum rises through the front tubes and again enters the upper drum.

In the Stirling boiler, a feed-water discharge pan is provided, located just below the water line so that the entering water passes down the rear bank of tubes, where it becomes heated to a temperature almost equal to that of the contained water.

### Water Column Connections

Extra heavy tees and crosses, with open ends plugged, should be used in the steam connection of a water column so that the pipe may be inspected. The column should be so placed that the bottom of the water glass is no less than 3 in. above the top row of tubes.

For high-pressure work, a flanged connection is the most satisfactory method of attaching a column. By supporting each column free from the pipe work, the piping is more secure, and the pipes may be disconnected without disturbing the columns or their connections.

Such connection pipes as pass through the boiler settings should be protected by pipe sleeves 2 sizes larger than the connection pipes. Pipe 1¼ in. in diameter is commonly used for water-column connections, the duty being virtually the same for any size boiler. If the connections are more than 3 ft. in total length, the column should be separately supported, and if separately sup-

ported the individual connections should not be much shorter than 3 ft., in order to provide for the differences in expansion of the boiler frame, front and connections.

Shown in Fig. 6 is a satisfactory method of piping a water column. The pipe leading from the top of the column to the steam space of the boiler is connected into the top of the boiler shell, or passes through the front breeching in the horizontal tubular boiler, and enters the front head above the point where it is desirable to carry the water. The cross, C', has a connection leading to the steam gage, E. In providing this connection, it is well to arrange the pipe as shown, as the accuracy of the gage may be tested at any time by attaching a test gage to the angle valve, F.

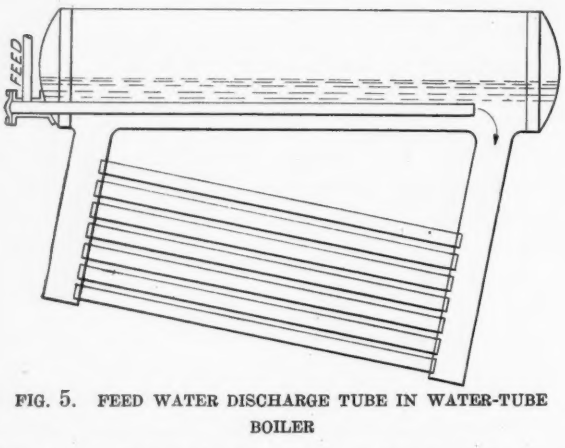



FIG. 5. FEED WATER DISCHARGE TUBE IN WATER-TUBE BOILER

From the cross, C, the water connection enters the boiler head or drum head, one branch of the bottom outlet taking the column blowoff connections, M, controlled by the valve L, to the ashpit.

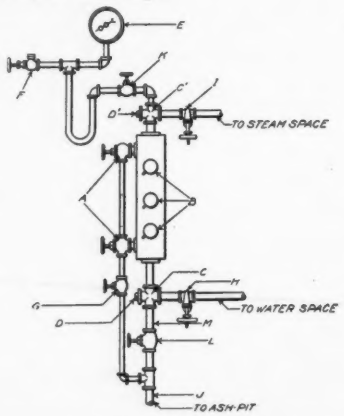
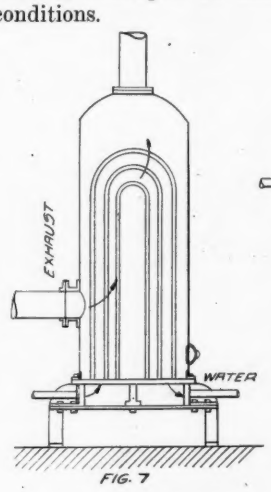



FIG. 6. FLEXIBLE ARRANGEMENT OF WATER COLUMN CONNECTIONS

It is considered good practice to remove the pet cock that is usually sent with the lower water glass fittings and connect in a nipple and valve, G, as shown, since a valve opening permits a freer discharge from the gage glass. This should be connected into the pipe from the column blowoff and thus discharged into the ashpit. No connections other than the steam gage should be attached to the column or its connections, as a draft of steam or water through them will cause an erroneous reading of the water level. Blowoff lines from the bottoms of the water column and gage should run separately down to a point within reach from the floor and a valve placed in each connection before it reaches the common discharge.

Valves H and I should be gate valves of the outside screw and yoke type and in some localities it is specified that these valves be locked or sealed open for normal operation. One advantage of having valves H and I in the water column connection is that it makes possible a more thorough clearing of the water connections. Without these valves there is no assurance that most of the blowing out does not take place in the steam connection.

With the arrangement shown, the water connection may be blown separately and therefore more effectively. This is accomplished, first, by closing I and leaving H open. Then with L open, the boiler pressure is concentrated on the area of the water connection, and the pipe is thoroughly washed out. Next, valve H is closed and I is opened, which will thoroughly clean the steam connection, then open H and close L, restoring normal conditions.



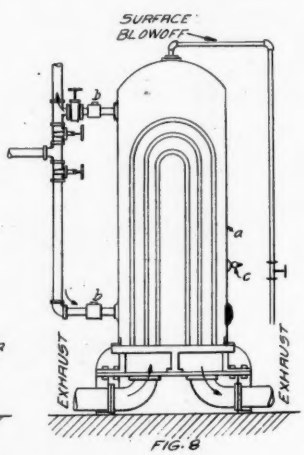




FIG. 7. WATER-TUBE TYPE OF HEATER
FIG. 8. STEAM-TUBE WATER HEATER

### Open and Closed Heaters

Owing to its ability to keep the feed water separated from the cylinder oil present in exhaust steam, the closed feed-water heater is more frequently employed than the open type.

There are 2 distinct forms of closed heaters, the water-tube and the steam-tube types, and both are equipped with flexible copper tubes. Figure 7 shows the water-tube type, and Fig. 8 shows the steam-tube type.

Two methods are employed for closed feed-water heater connections. For the steam-tube type of heater, the "through" connection, as shown in Fig. 8, is commonly used. With this arrangement, all of the steam passes through the heater under ordinary conditions, although a portion may be deflected through the bypass if desired. In the "induction" arrangement, the piping is simplified and the number of valves reduced by making a single steam connection to the heater. This is done in such a manner that steam will tend to be driven into it before any of the surplus passes outboard. Either method will operate satisfactorily when properly installed, and choice between them is usually governed by the available space or other local conditions.

# Blowoff Piping

FOR the proper removal of scum, precipitated scale forming materials and mud, every boiler is provided with one or more blowoffs, and, in order that the boiler may be completely emptied, it is necessary that the blowoff pipe should be connected at the lowest point of the boiler. For general high-pressure service, the blowoff pipe should be of extra heavy material and capable of withstanding from 175 to 200 lb. pressure.

Different methods are employed for protecting blowoff pipe wherever it is exposed to the fire in the combustion chamber. In most water-tube boilers, it is located well away from the hottest part of the fire so that it is only necessary here to consider the blowoff piping of a return tubular boiler.

Two common methods of arranging blowoff piping are shown in Figs. 1 and 2. In the first instance, the descending pipe is protected from the heat of the gases by a sleeve of fire brick, although a V-shaped pier of fire brick, with the point toward the front of the boiler, is sometimes employed. The horizontal pipe is bricked over or covered with a coil of plaited asbestos rope ½ to ¾ in. in diameter. Figure 2 shows the bottom blowoff pipe provided with a circulating pipe which enters the rear head of the boiler. Where the blowoff pipe passes through the rear wall of the setting, it should be surrounded by a sleeve, so that it will be free to move. To prevent air leaking in, the space between the sleeve and the pipe should be packed lightly with asbestos rope or a similar substance without interfering with the free movement of the pipe.

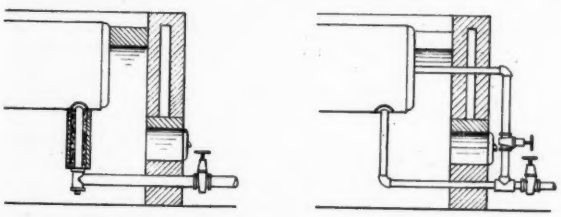



FIG. 1. BLOWOFF PIPE PROTECTED BY FIRE-BRICK SLEEVE
FIG 2. BLOWOFF CONNECTION WITH CIRCULATING PIPE

Diameters of blowoff pipes for tubular boilers are commonly as follows: 1½-in. pipe for boilers up to 42 in. in diameter; 2-in. pipe for boilers up to 60 in. in diameter, and 2½-in. pipe for larger boilers. In low-pressure and water-tube boilers, the size of the blowoff is determined by the manufacturer, a tapped boss at the lowest point indicating the size of pipe to be used.

A number of boilers may be connected to one common blowoff header; and since, in general practice, but one boiler is blown down at a time, the diameter of this header may be only 3 or 4 in. All branches should connect to the header by means of a "Y" to minimize resistance due to mud, etc. It is advisable to design the blowoff branch leading from the boiler to the header so that the severe strains due to extreme expansion and contraction will not affect them. Short and rigid connections should be avoided and all possible flexibility given.

Each blowoff line should be provided with a valve especially designed for this purpose, supplemented by a gate valve. On account of the rather severe service to which they are subjected, blowoff valves are usually made extra heavy, with removable disks and seats. Globe valves are never used because they do not readily provide a free passage for the sludge and scale. When the boiler is blown down, the valve next the boiler should be opened first, then the outer valve is opened. In closing, this order should be reversed, the valve nearest the boiler is closed last. In this way, the valve nearest the boiler remains in good condition, prevents leakage, and enables the outer valve to be replaced if necessary without shutting down the boiler. All fittings on the blowoff line should be of cast steel.

### Surface Blowoff

Boilers are frequently fitted with a surface blowoff, which is simply a 1 or 1½-in. pipe carried through the shell or head with a bushing, and fitted with a funnel-shaped opening as shown in Fig. 3. This pipe is provided with a cock or valve, and serves to remove floating impurities that would finally settle to the bottom of the boiler if not removed. The surface blowoff and bottom blowoff piping can be advantageously combined in such a manner that a constant circulation is obtained.

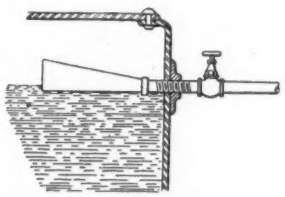


FIG 3. SURFACE BLOWOFF PIPE

### Blowoff Tanks

In buildings in cities where it is not permitted to blow down a boiler under steam pressure, discharging hot water into the sewer, it is customary to provide a tank into which the water is discharged and allowed to cool before being run into the sewer. Figure 4 shows a tank constructed for this purpose.

Size of the blowoff tank depends upon the number of boilers to which it is connected. In some plants, where 12 to 18 boilers are connected to one tank, the tank may be from 5 to 6 ft. in diameter and from 6 to 8 ft. in height, and made of rolled steel. In smaller plants, a horizontal tank 3 ft. by 6 ft. is commonly employed.

Blowoff tanks should be provided with an overflow pipe and a vent, which may discharge either directly to the roof or to the atmospheric exhaust pipe; in some instances, it is connected to the auxiliary exhaust and discharged through the heater. Where conditions permit, the tank may be a pit constructed of brick or concrete. Frequently the vent pipe is not sufficiently large, thus allowing steam to be carried into the sewers, and also, since it fails to relieve the pressure, permitting water to be discharged through the vent.

In many instances, a blowoff cistern, as shown in Fig. 5 is employed, which is located about 50 ft. from the building and has an open grating to permit the escape of

steam. This cistern is constructed as a storage for the blowoff water, with its discharge valves set so that the rate of discharge into the sewer will be small. Such a cistern should have a storage capacity of not less than 70 cu. ft. To permit its removal, the pipe from the building to the cistern should be inclosed in a tile sewer pipe.

Opening A, in the building wall, should have a clear space in front of it to permit the removal of a full length of pipe in order that the entire blowoff main may be

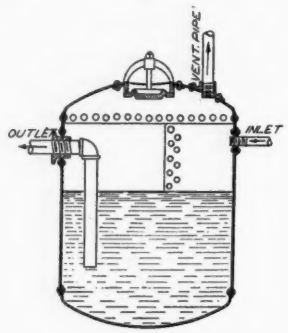



FIG. 4. BLOWOFF TANK

removed if necessary. The slipjoint at the cistern end will afford a convenient means for closing the opening in the cistern, permitting at the same time a free movement of the pipe line in the boiler room. An old brass valve not over 2½ in. in diameter, may be used as the regulating valve in the cistern, as it will neither be under pressure nor closed tight. The check valve in the boiler room should not be less than 1 in. in opening, as the discharge end of the blowoff will be under water and any vacuum formed in the blowoff main should be

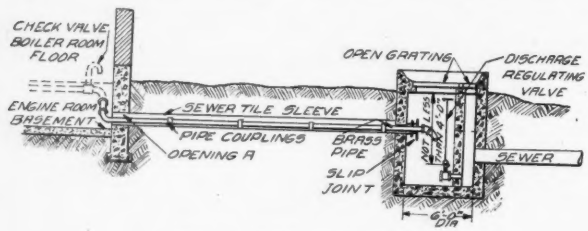



FIG. 5. BLOWOFF CISTERN

broken without drawing cistern water back into the line. To avoid water hammer, the blowoff main back of the boilers should be located above the high-water level of the cistern.

### Heater Blowoff

Closed heaters require a blowoff at the lowest point in the water space, the precipitation being in the form of mud and not likely to injure the valve. It is best, however, to employ 2 blowoff valves, as with boilers; for if but one valve were used, it would be necessary to have a wash-out tee next to the heater. Live steam purifiers should have similar protection and means for cleaning. The washings from any station device should discharge in plain view, so that the operator can see what is being accomplished.

# House Service Piping

Supply Systems, Piping for Hot Water, Air Washing Systems, Elevator Piping and Drinking Water Supply

Water for convenience of occupants in various parts of low buildings is furnished at comparatively low pressure, usually about 20 lb. It is customary to supply this from an elevated tank or city mains rather than direct from a pump. For factories the estimated amount of water used a day is 100 gal. per capita. In high office buildings where the supply tank is located on the roof it is necessary to use pressure reducing valves for the lower floors to prevent an excessively high pressure on the plumbing fixtures. In such cases the pressure on the different floors varies from 10 to 100 lb.

Cold water service piping is extremely simple, consisting of a single main with branches to fixtures. The water is delivered to the roof tank up through the main and fed down as needed to the fixtures, except where pressure reducing valves are required, when separate supply and service mains are necessary below the location of the reducing valve.

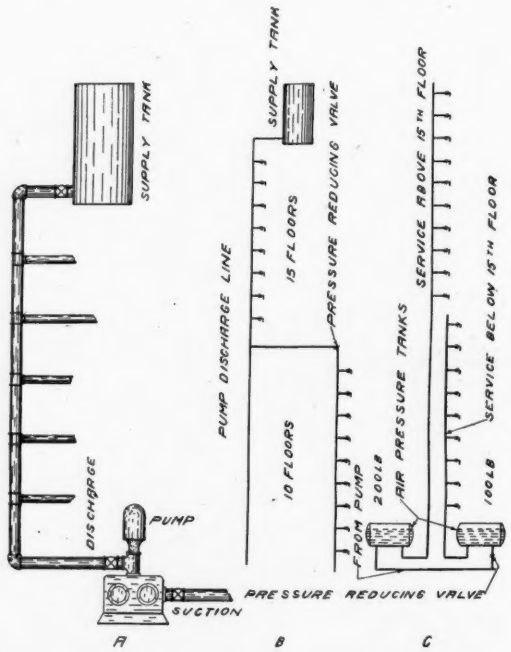



FIG. 1. SERVICE PIPING ARRANGEMENTS

In place of the elevated tank feeding by gravity, some plants have air pressure tanks in the basement which force the water to the different floors. Figure 1 shows 3 arrangements for supplying water: A, direct gravity; B, by gravity direct and through reducing valve; and C, by air pressure. In the latter case, a high-pressure tank serves the top floors and a low-pressure tank, the lower part of the building. One pump may be used for this arrangement, a pressure reducing valve feeding into the low-pressure system. The low-pressure air tank prevents abnormal pressure on the low-pressure fixtures due to a leaky reducing pressure valve.

Supplying hot water is usually a difficult detail to arrange as it will cool during transmission and while lying still in the fixture connection. With single piping great quantities of cool water are allowed to run to waste before hot water is secured, unless the faucets are close to the heater.

In the power plant lavatory, hot water may be taken direct from the boiler feed main at boiler pressure, but this presents objectionable features in that it robs the boiler of water and necessitates high pressure plumbing fixtures. Reducing valves might be used but a slight

DIMENSIONS OF COIL HEATERS

| Tank | Coil | Connections | | |
|---|---|---|---|---|
| | | Water | Steam | Heater |
| 18"x 5' | 15'x 1-1/4"OD | 1"<br>1"<br>3/4" | 1-1/4"<br>1" | 1-1/4" |
| 24"x 7' | 25'x 1-1/2"OD | 1-1/4"<br>1-1/4"<br>1" | 1-1/2"<br>1" | 1-1/2" |
| 36"x 8' | 35' x 2" OD | 1-1/2"<br>1-1/2"<br>1" | 2"<br>1-1/2" | 2" |

leak will cause the pressures to be practically equalized with resultant difficulty at the faucets unless high pressure fixtures are used.

Live steam is commonly used for heating house water, the arrangement of the coil depending upon the amount of hot water required; in all cases, however, the steam supply to the heater should be under thermostatic control so that the water will not reach the boiling point when the demand for hot water is light.

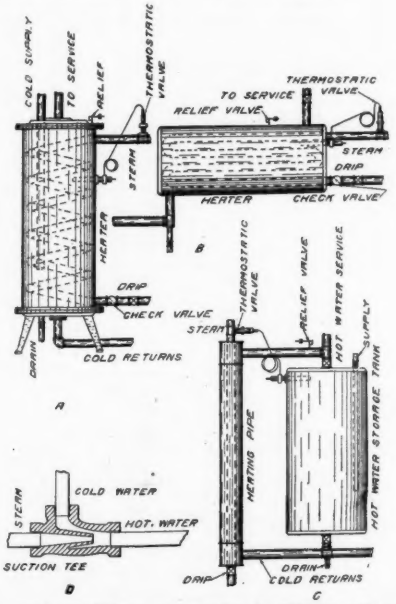



FIG. 2. CONNECTIONS TO SEVERAL TYPES OF HEATERS

Exhaust steam is convenient for heating house water as the temperature will never exceed the boiling point and the heater can be proportioned to give the necessary supply at the desired temperature.

The type of heater to employ depends upon the service demanded. Where large quantities of hot water are required almost continuously the tank type containing a properly proportioned steam coil is most suitable. This may be either vertical or horizontal, as shown in Fig. 2, A and B. Where a large quantity is used only at intervals, the arrangement shown at C has advantages. In this, comparatively small heating surface is employed apart from the main body of water, which is heated by circulation through the heating pipe and storage tank. By proper proportioning to the demand this arrangement gives good results and provides an independent heating element that is easily cleaned or repaired. Where steam is always available an instantaneous heater, made by connecting a suction tee to the steam and cold water piping, as shown in Fig. 2D, has the advantage of being inexpensive and is frequently employed in washrooms of power plants and factories.

In Fig. 3 is shown a commercial heater which automatically maintains the water the desired temperature by employing its own expansion to operate the steam inlet valve. The pipe connections to the steam inlet and water outlet of this heater must provide for the expansion of the heater; rigid piping is likely to cause leaks to develop.

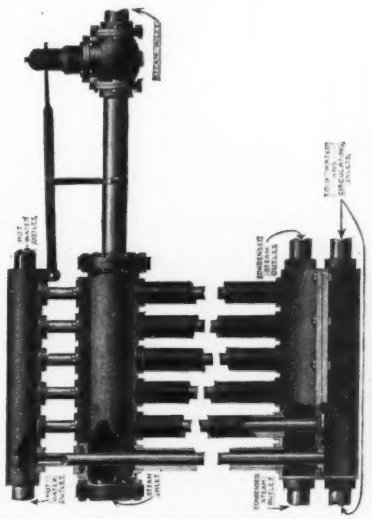


FIG. 3. PART SECTIONAL VIEW OF THE THERMAL APPLIANCE CO.'S MADSEN HEATER

Tank type heaters are usually made with sufficient storage capacity, but if occasion demands, storage tanks may be connected up in a manner similar to that shown in Fig. 2C. All hot water pipes, heaters and storage tanks should be thoroughly insulated to prevent waste of heat.

Heating coils are usually made of brass or copper tubing and in estimating the amount of heating surface, the calculations are based on the transfer of 200 B.t.u. per sq. ft. of surface per hour for each degree difference in temperature between the water and the steam. Heaters are sometimes proportioned on the basis of 1 ft. of 1-in. iron pipe for each 5 gal. in the tank, on the assumption that the contents are to be heated from 50 to 180 deg. every hour, steam at 2½ to 3 lb. pressure being used. Dimensions of pipe coil heaters as installed for the U. S. Government are given in the accompanying table.

To secure hot water at the faucets without excessive waste requires careful planning of the piping system.

By means of a return pipe, the water in the main may be maintained hot but the lines from the mains to the faucets, unless kept running, will get cool and for this reason should be no larger than necessary and as short and direct as possible.

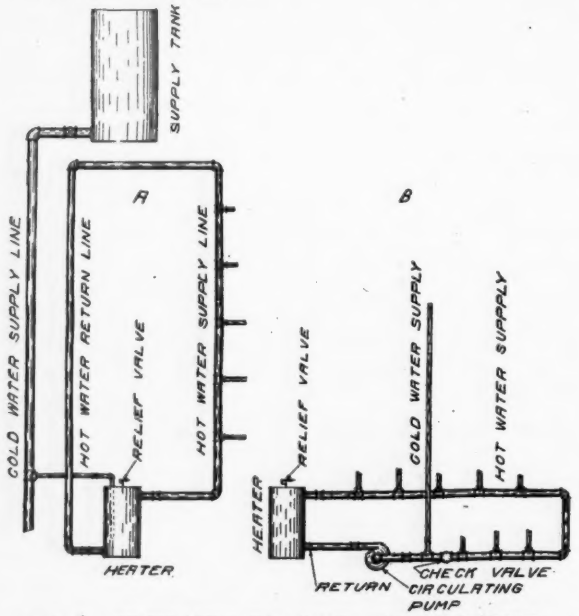



FIG. 4. CIRCULATING HOT WATER SERVICE SYSTEMS

When the return loop system of hot water circulation is employed, hot water may be drawn from any part of the main or return. Where the hot water mains are mostly horizontal it may be found necessary to force the circulation, the means employed being usually a centrifugal pump.

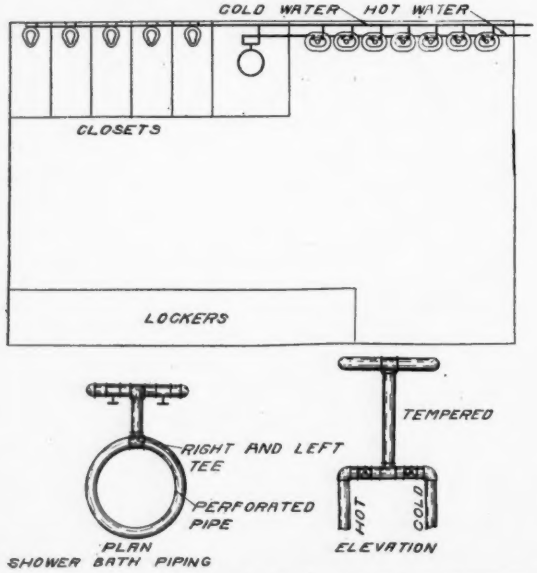



FIG. 5. PLAN OF PIPING FOR WASH ROOM AND CLOSETS

## Toilets and Washrooms

For toilets and washrooms in power plants the water is usually under city pressure, but in some cases hot water is taken from the boiler feed mains when boiler pressure must be carried in the fixtures. While this is objectionable practice, it is cheaper than to install a heater when only small quantities of hot water are required. In such cases an instantaneous heater consisting of a suction tee with steam and water connections serves the purpose nicely.

For convenience in piping, wash bowls and closets are placed in rows so that all fixtures can be connected by a short pipe to the service pipes; shower baths, also, may be connected to this piping as illustrated. Two

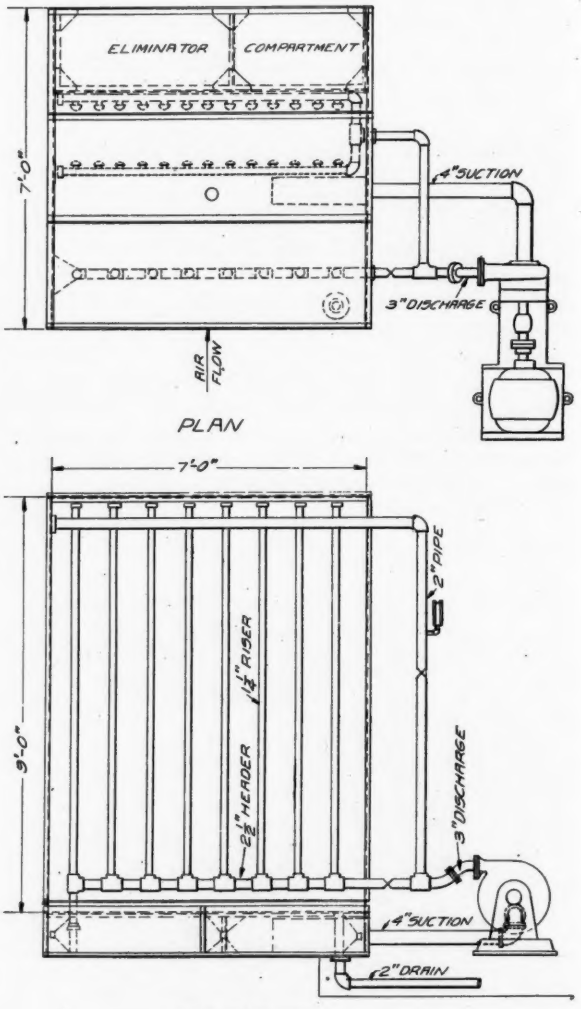



FIG. 6. TYPICAL AIR WASHER PIPING

points to look out for in this piping work are to allow no dead end or conditions that cause water hammer. Dead ends quickly become fouled, causing pipe corrosion and bad water, while water hammer frequently causes broken fittings. Galvanized pipe is preferable for this work as it resists corrosion.

## Air Washers

Water for conditioning air is usually allowed to settle and used over again, the circulation being maintained by a centrifugal pump. The loss due to evaporation is

not great approximating 1.1 gal. per 1000 cu. ft. of air. This may be supplied to the settling tank direct from the service lines, either through an automatic float valve or periodically by an attendant.

### Elevators

Where an elevator is used for power plant purposes it is usually of the hydraulic lift type employed for lifting coal or ash cars short distances, 10 to 20 ft. The water for such a lift is furnished at a pressure obtainable in the plant without extra pumps. A reserve boiler feed pump serves well for this purpose, but frequently the service water pressure, if 60 lb. or over, is used for this purpose. Piping to such an elevator is extremely simple, consisting of a pipe leading from the pressure system through a 3-way valve, or better still, a special hydraulic elevator valve, to the plunger cylinder; a waste water pipe leads from the 3-way valve to a surge tank from which the water can be pumped back into the system. The proper size of piping is about ¼ the size of the plunger. When a boiler feed pump is used for this purpose it should discharge into an air pressure tank

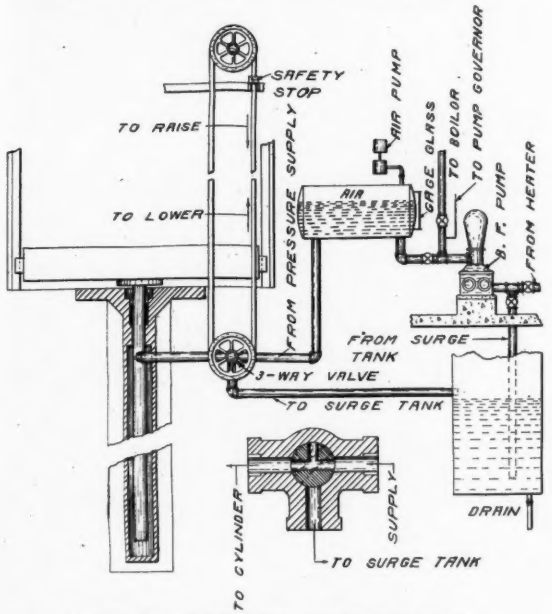



FIG. 7. PIPING FOR HYDRAULIC LIFT

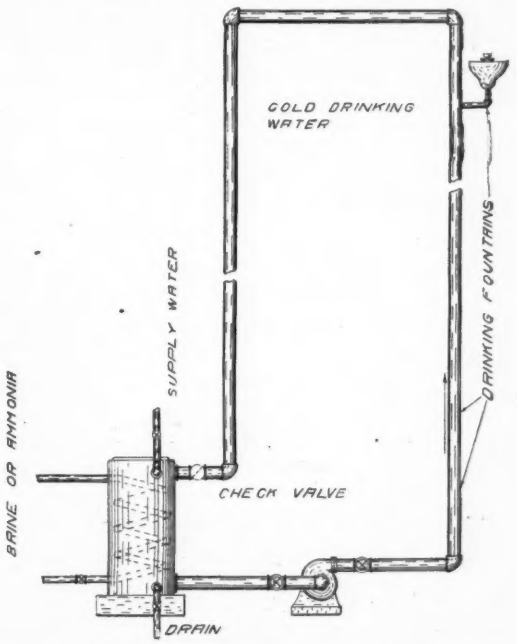



FIG. 9. PIPING FOR CIRCULATING COLD DRINKING WATER

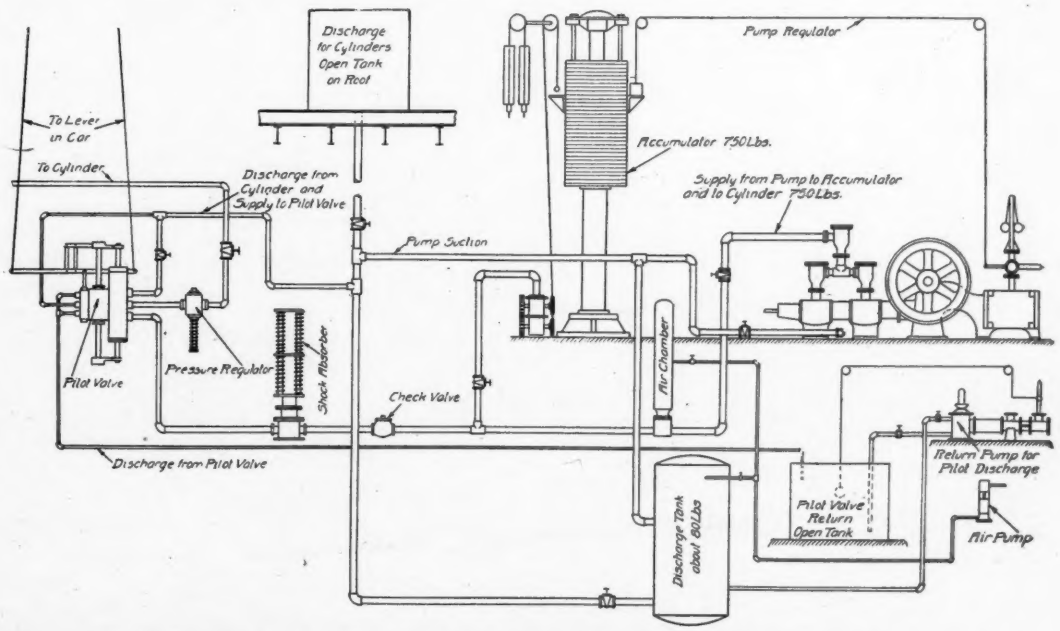



FIG. 8. PIPING SYSTEM FOR HYDRAULIC ELEVATOR EMPLOYING AN ACCUMULATOR (JALLINGS)

and be controlled by a pressure regulator and pump governor. This arrangement will put a more even load on the pump and give the elevator a smooth steady lift.

Hydraulic elevators for office buildings are usually under the care of the engineer and in Fig. 8 is shown typical piping of a system employing an accumulator.

### Cold Drinking Water

Fresh cold water to drinking fountains is one of the luxuries in many office buildings. This is supplied from a circulating system very much as is hot water, the difference being that a water cooler is used instead of a heater. The fixture is always close to the supply pipe to prevent waste of cold water, and the circulation must be forced unless the cooler is located at the top of the system which is not usually advisable.

## Fire Service

### Pump, Hydrant, Standpipe and Hose Connections; Roof Tanks and Sprinkler Systems

When pumps are not used exclusively for fire service, it is essential that separate discharge lines, each provided with the necessary shutoff valves at the pump, be installed. In case of fire, therefore, these valves being grouped, may be operated in the shortest possible time, and, as a further aid, an established system of tags or painting may be followed as, yellow valves closed; and red valves open.

The same results, but with the uncertain human element eliminated, may be obtained by means of the automatic device illustrated in Fig. 1. With the pump

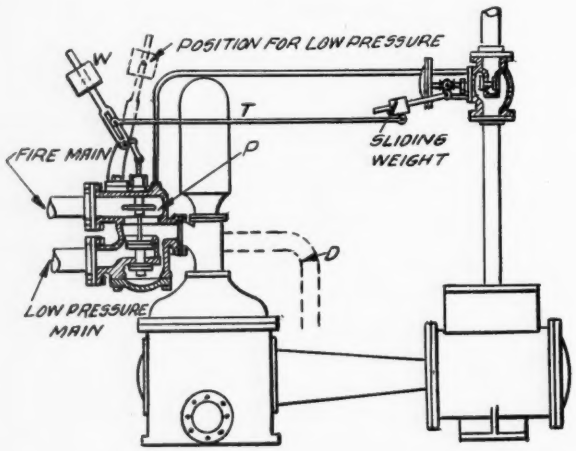



FIG. 1. AUTOMATIC PRESSURE REGULATING DEVICE FOR FIRE PUMPS

serving the low-pressure main, the arm supporting weight W is in the dotted position with loose piston P covering the high pressure main discharge opening. Upon the opening of any single hydrant, a flow is established through the high-pressure line which raises loose piston P, shutting off the low-pressure supply and tilting weight W to the full-line position. This, through the medium of tie rod T shifts the sliding governor weight, which, in turn, acts upon the governor, causing admission of more steam and building up of the necessary pressure.

A continuous supply of water to the pumps may be insured by providing a suction connection with the local city water supply discharging into an open well or other point convenient to the regular pump suction.

As an aid to keep the system in operation the longest possible time during a fire, steam-supply and water lines should not be suspended from overhead, but should be so supported and protected as to remain intact even if the roof and floors above fall on them.

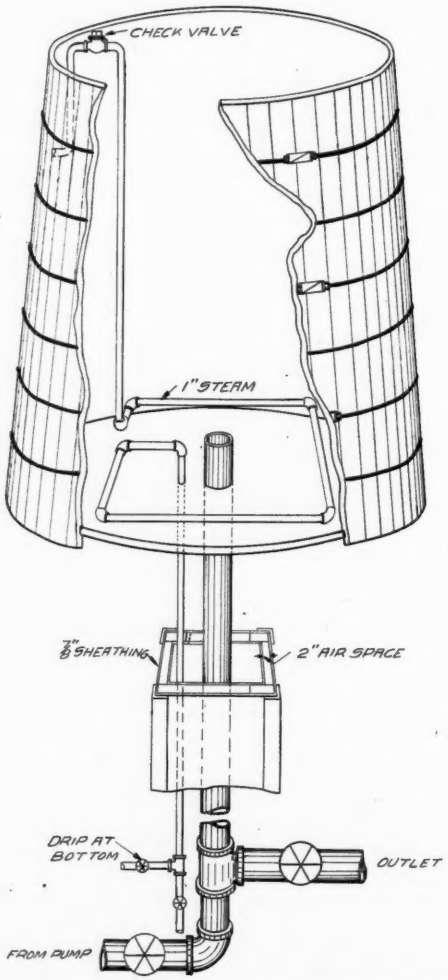



FIG. 2. ROOF TANK CONNECTIONS, SHOWING ARRANGEMENT OF HEATING COILS AND METHOD OF FROST PROOFING

### Hydrants and Hose Lines

Fire mains supplying hydrants and standpipes are generally laid out to conform to local requirements and conditions, although wherever possible some form of loop should be employed, thus permitting any section to be shut off and still maintain sufficient fire protection. To avoid possible freezing and to facilitate proper hydrant connection, mains should be buried to a depth of no less than 5 to 6 ft., and where supplying important buildings, should be at least 6 in. in diameter.

The hydrants which should be provided with 2 or more 2½-in. outlets and with an inlet equivalent in size to the main should be placed at a distance from the building equal to its height and with hose connections facing the building. They should be located at such intervals that not more than 300 ft. of hose need be laid in any one line, and so that about 10 first-class fire streams can be concentrated on any large building.

Standpipes carried on the outside of buildings should be provided with one or 2 hose connections with valves at each floor and possibly 2 such connections at the roof; a valve and drain at the lower end of the standpipe is desirable to clear the line of water after use and prevent freezing. No pipe smaller than 4 in. in diameter should be used for this service and when 2 connections are taken off at each floor a 6-in. standpipe is advisable.

Roof tanks used in connection with sprinkler systems should be so placed as to furnish a minimum head of 25 ft. and of such size as to provide a continuous supply of water to all the sprinklers in any fire section for a period of 20 min., assuming each such sprinkler to require 20 gal. per minute. Standard tank sizes range from 10,000 to 50,000 gal. capacity.

TABLE I. SPACINGS OF AUTOMATIC SPRINKLER FOR PRESSURES GREATER THAN 20 LB. PER SQ. IN.

| Kind of hazard* | Spacing of sprinklers, ft. | | | | | | |
|---|---|---|---|---|---|---|---|
| | Standard mill construction | | | | | Open-joisted ceilings | |
| | Width of bay, ft. | | | | | Sprinklers at right angles to joists | Sprinklers parallel with joists |
| | 12 | 11 | 10 | 9 | 8 and under | | |
| Medium | 8 | 9 | 10 | 11 | 12 | 8 | 10 |
| Special | 7 | 8 | 9 | 10 | 11 | 7-1/3 | 9 |

* The terms "Medium hazard" and "Special hazard" relate to the contents or occupancy of each room. Specially hazardous places are such as picker rooms, planing or sawing departments of wood-working establishments, painting or varnishing rooms, etc.

For pressures less than 20 lb. per square inch use spacings 1 ft. less than the above.

Three common methods of supplying roof tanks with water are by the use of a float and lever connected to the steam pipe of the pump; the use of a float and lever arranged to operate the water valves in the line discharging into the tank, and by means of a float, pulley and telltale placed on the wall, enabling the operator to observe and control the feeding arrangement by hand.

## Fire Hose

Fire hose is made in 3 standard sizes, namely, 2, 2½ and 3 in., and varies in quality from the roughest, the unlined linen or cotton woven to the smoothest, the heavy rubber lined so well filled with rubber that the inside remains smooth even under high pressure.

When purchasing fire hose, it should be tested not only for strength to resist bursting, but also for pressure drop. In the best grade this drop will amount to about 15 lb. per square inch for each 100-ft. length, while in rough hose of lower quality this drop will exceed 30 lb. per square inch with a flow of about 240 gal. per minute.

## Sprinkler Systems

In laying out sprinkler systems, the most effective distribution of water may be obtained by providing central feed lines and short branches wherever possible, reduction and elimination of friction losses, provision for proper drainage, use of long turn fittings and bends and the prevention of sagging of the lines due to insufficient or improperly spaced hangers.

In determining the size of feed mains and risers, each floor or fire section of a building is considered as one unit. Any number of floors or fire sections may be placed on the same riser and that having the largest number of sprinklers determines the required size of feed main or riser. Where, however, the number of sprinklers on any floor or fire section exceeds 200, additional risers should be provided and unless absolutely necessary no more than 8 sprinklers should be placed on any branch line. At least one sprinkler should be allowed for every 100 sq. ft. of floor area, the sprinklers never to be more than 12 ft. apart in either direction and preferably not more than 10 or 11 ft.

TABLE II. ROOF TANK DIMENSIONS AND SIZES OF CONNECTIONS

| Gal. Capacity | Av. Diam. | Ht. | Hoops No. | Hoops Diam. | Water Pipe Diam. | Heating Coil** 1" Pipe |
|---|---|---|---|---|---|---|
| 10,000 | 13'-4" | 12' | 11 | 3/4" | 5" | 30' |
| 15,000 | 14'-6" | 14' | 14 | 3/4" | 6" | 35' |
| 20,000 | 15'-6" | 16' | 5<br>11 | 3/4"<br>7/8" | 6" | 45' |
| 25,000 | 17'-6" | 16' | 4<br>12 | 3/4"<br>7/8" | 8" | 60' |
| 30,000 | 18'-0" | 18' | 4<br>16 | 3/4"<br>7/8" | 8" | 70' |
| 50,000 | 22'-0" | 20' | 23 | 7/8" | 10" | 100' |
| 75,000 | 24'-6" | 24' | 4<br>6 | 7/8"<br>1 "<br>1-1/8" | 12" | 150' |
| 100,000 | 28'-6" | 24' | 5<br>9 | 1 "<br>1-1/8" | 16" | 200' |

** To heat water 10 deg. in 30 min. using low-pressure steam.

Dry-pipe systems should be so arranged, if possible, that all pipe lines drain back to one main drip valve located at or near the dry-pipe valve.

Placing the dry-pipe valve as near the main riser as possible is desirable, and under no conditions should this valve control more than 300 sprinklers. Where exposed to cold, the valve should be located in an approved underground pit or enclosed in a room or closet of sufficient size to give preferably 30 in. free space on all sides of and above and below the valve.

All distributing piping should pitch back to the riser not less than ¼ in. in 10 ft. with the riser as near the distributing center as possible.

The number of sprinklers capable of being cared for by various sized pipes is indicated below:

Pipe Sizes for Sprinkler System

| Size of Pipe, in. | No. of Sprinklers | Size of Pipe, In. | No. of Sprinklers |
|---|---|---|---|
| ¾ | 1 | 3 | 36 |
| 1 | 2 | 3½ | 55 |
| 1¼ | 3 | 4 | 80 |
| 1½ | 5 | 5 | 140 |
| 2 | 10 | 6 | 200 |
| 2½ | 20 | ... | ... |

Wherever pipe under air pressure, as used in the dry-pipe system, is placed underground it should be of wrought iron painted on the outside with 2 coats of good rust-proof paint as asphaltum or tar, one coat before pipe is laid and the final coat after being placed in position with joints screwed tight.

All valves must be of the Underwriters Approved Pattern, and when 2½ in. and over in size must have flanged ends, while those 2 in. and under may have screwed ends.

# Condensers

## Arrangement and Connection for Various Types

TWO general schemes of condenser installation are employed, namely, the independent or subdivided system and the central system. In the former, that confined principally to central stations and those plants having large turbines, each unit is provided with its individual condensing equipment; in the central system, particularly well adapted where the exhaust steam is used for heating and the requirements are more or less variable, one condenser suffices for all engines, connections being such that the entire plant, or any part of it, may be operated either condensing or noncondensing.

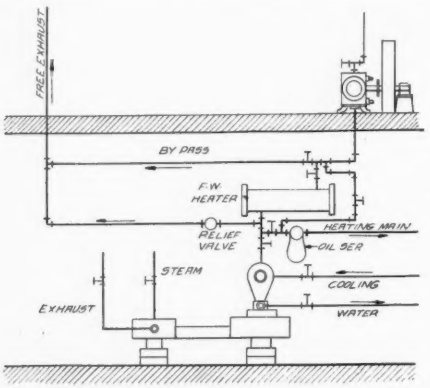



FIG. 1. PIPING DIAGRAM FOR JET CONDENSER IN CONJUNCTION WITH FEED-WATER HEATER

Water for condensing purposes may be obtained from a nearby stream, lake, well or the local water system, in which case, however, there may be some question as to the saving in installation and operation justifying the expenditure necessary for the added equipment.

Local conditions permitting, the water is generally allowed to flow by gravity through tile, concrete or iron intakes into a cold well or cistern located in the power house as near the condensers as possible. With the plant at a considerable elevation above the source of supply and where elevated jet or barometric condensers are employed, these may be placed so as to allow the exhaust to drain into the condenser; in the case of a surface condenser installation, a sealed circulating-water system discharging into the source of supply will act as a syphon, thus reducing the circulating pump head to friction and velocity only.

Screens placed in the intake to prevent the entrance of leaves, fish, sticks, ice, etc., are usually made of iron mesh or bars with openings the same size as condenser tubes or ⅛ in. smaller, these are set in frames operating in slides for cleaning purposes and are enclosed in cast-iron or concrete screen boxes or cribs. A late development for use in large plants consists of self-moving screens arranged either drum fashion or like a chain grate set on end. The velocity through screens should not exceed 4 to 5 ft. per second.

As a measure of precaution against possible shut down due to a shortage of condensing water, a city-supply connection to the cold well is recommended.

Jet condensers may be installed either as shown in Fig. 1, or elevated. With the former arrangement, the engine exhaust may pass through the feed-water heater

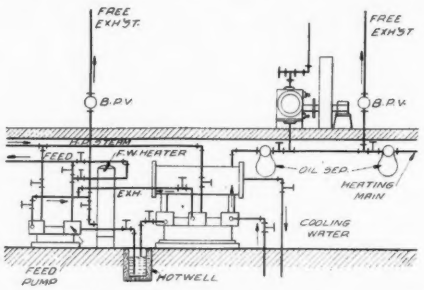



FIG. 2. PIPING DIAGRAM FOR SURFACE CONDENSER

and either to the condenser, the heating system or the atmosphere; or by means of the bypass the heater may be cut out for cleaning and repairs.

Injection and discharge line sizes are largely fixed by the sizes of their respective connections in the condenser shell, which for the former are generally based on a velocity of water flow ranging from 400 to 600 ft. per minute and that of the discharge pipe on velocities of from 200 to 400 ft. per minute. With an allowable velocity of 600 ft. per minute, Marks' Mechanical Engineers' Handbook recommends making the discharge pipe diameter equal to 0.0765 times the square root of the

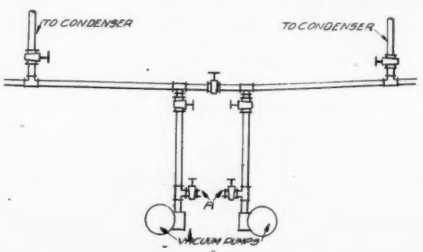



FIG. 3. ARRANGEMENT OF DRY VACUUM MAIN WITH CONDENSER AND PUMP CONNECTIONS

number of pounds of steam condensed per hour and that of the injection pipe equal to the diameter of the discharge pipe, minus 1 for small condensers, and minus 2 for large sizes.

If, due to the condenser being too large for its work, a reduction in injection and discharge pipe size is advisable, this should always be made by means of tapering reducers; never use bushings.

## Barometric-Condenser Connections

As barometric condensers depend upon the use of a barometric column for the removal of condensate, cooling water, and sometimes the entrained air and other noncondensible vapors, it is essential that the mixing

cone be at least 34 ft. above the high-water line in the intake, or hot well, if such is used, allowing the height of the condenser as leeway to prevent flooding.

Injection water and tail-pipe diameters are found in the same manner as for jet condensers, and as in these the relative location of injection water and exhaust steam inlets varies considerably, some builders placing the former above the latter, while in others the steam is introduced above the cooling water inlet, either through an opening at the side of the shell or directly through the top.

The injection pipe should be fitted with a valve to control the flow of water, and to prevent the entrance of leaves, sticks, small fish, etc., it is desirable to provide it with a strainer of ample size.

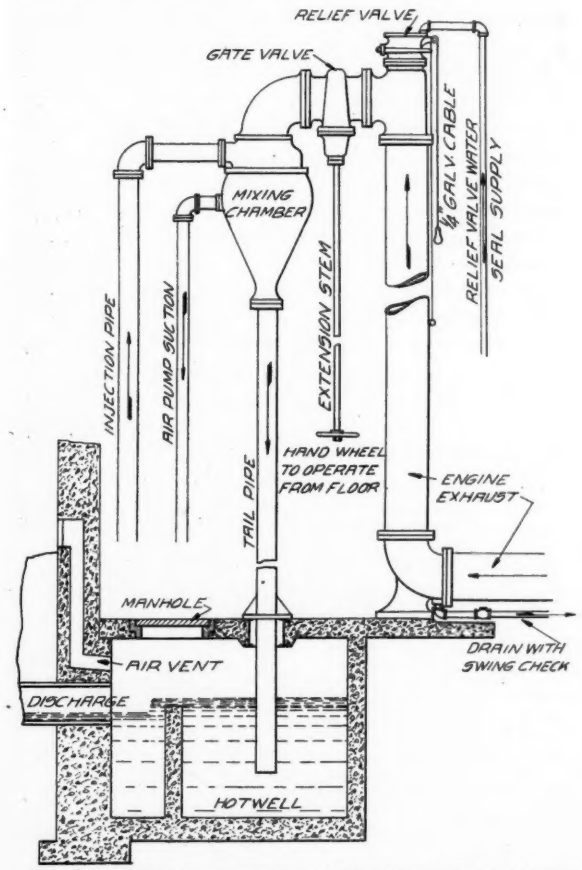



FIG. 4. TYPICAL BAROMETIC CONDENSER INSTALLATION

Installations in which the mixing cone is more than 20 ft. above the source of injection supply will require a pump; where less than 20 ft., the vacuum created in the condenser will be sufficient to raise the injection water, if some form of forced injection is provided for starting. This may be accomplished also by running a horizontal line fitted with a gate valve from the injection water line to tail pipe, the water flowing through this connection and down the tail pipe gradually exhausting the air from the upper part of the tail pipe until sufficient vacuum is created to draw the water up to the mixing chamber. When this is established, the valve in the cross connection is closed.

As few fittings as possible should be used on the tail pipe and if for any reason a change of direction is necessary, long-sweep bends should be employed. The hot well, if such is used, should have a volume of at least 4 times that of the tail pipe; this should be sealed by at least 18 in. of water above the outlet, which in turn must clear the bottom of the well by 6 in.

Base ells on exhaust and injection risers will provide sufficient support for condensers up to about 10 to 12 in., the whole outfit, however, being braced to a nearby wall by A braces. For larger units, special provision must be made for the support of the tail pipe, either by means of a tripod attached to the base flange or some form of special fitting supported by I beams stretched across the top of the hot well. In no case should a base ell or any other sort be used in the tail pipe.

The diameter of the air or dry vacuum connection may be made 1/3 that of the tail pipe for 26 to 27-in. vacuums, to be increased slightly for a 28-in. vacuum.

### Surface-Condenser Connections

In the scheme of piping connections for a small surface-condenser installation shown in Fig. 2, the valve arrangement is such as to permit the exhaust steam to pass through the condenser, into the heating system or out to the atmosphere. Water for boiler-feed purposes

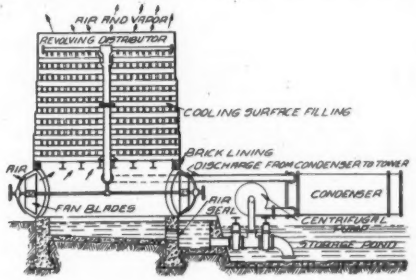



FIG. 5. SCHEME OF CONNECTIONS EMPLOYED IN COOLING-TOWER INSTALLATIONS

is taken from the hot well and passed through a feed-water heater supplied with steam from the auxiliary pumps.

Cooling water is usually introduced at the bottom of the shell and caused to leave through an outlet on top, the size of these connections being figured for a velocity of 8 ft. per second; the air connection should be at least twice that of the hot well pump suction, which should be figured for about 4 ft. per second.

While small condensers of the surface type are generally mounted upon a combined steam-driven circulating and condensate pump, those used in connection with large generating units are supported by the main foundation and are served with circulating water from a general system instead of individual pumps, valves being provided to shut off the flow of water to allow cleaning and repairing the condenser.

### Dry-Vacuum Connections

These should always be made at the highest point of the condenser and where a number of dry-vacuum pumps serve a like or greater number of condensers interchangeably, a dry-vacuum main is necessary. This should pitch slightly toward the air pump openings

wherever possible to prevent the accumulation of condensation, and should be tapped at the top for the condenser branches and at the bottom for the pump connections, thus insuring the removal of condensation in small continuous amounts. To avoid the possibility of the pump branch filling with water, a valve should be placed in this line directly below the main; valves on the main between the various pump branches will permit sections of the main being cut out for repairs without interfering with the operation of the plant.

Globe valves having a diameter no less than ¼ that of the pump suction and attached as shown at A, Fig. 3, permit bringing the pump up to speed before taking full vacuum.

After the pump is in operation, the branch line valves should be opened slowly to permit water accumulated above them to leak past and through the pump.

Hot wells located in engine rooms and boiler rooms should be ventilated as shown in Fig. 4, and to prevent the discharge of foul gases and vapors, manhole covers and the tail pipe should have an air-tight fit at the top of the well.

### Cooling-Tower Connections

With the upper row of cooling tower trays below the condenser or hot well outlets, the discharge from these may be allowed to flow over the trays by gravity,

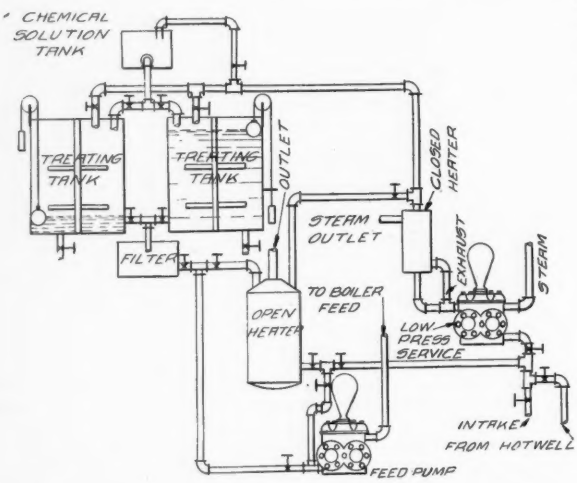



FIG. 1. ARRANGEMENT OF INTERMITTENT SOFTENING SYSTEM

while if above the condenser or hot well outlets, it will be necessary to employ a pump to handle this water. An exception to this may be found, however, in the case of a surface-condenser installation, as shown in Fig. 5, where, due to the closed circuit, the circulating pump is employed to force the condenser discharge to the cooling tower, up through the standpipe and out of the distributor. Cooling towers may also be placed above the condenser, the water from the storage basin flowing through an injection pipe directly into the mixing chamber in the case of a jet condenser.

In the case of a surface installation, as in Fig. 5, a storage pond may be used in conjunction with the system, the water being taken from the storage basin through a water seal employed to prevent the escape of air through the water outlet. Gate valves placed on either side of the pump suction allow circulating water to be drawn from the storage basin, the storage pond, or both.

Pipe bends should be employed instead of ells, and if the lines between the cooling tower and the condenser are of considerable length, it is always good practice to increase their size above that of the condenser outlets, as the fixed yearly cost on the difference in the investment is less than that saved in operation.

# Water Treating Systems

### Softeners, Heat Treatment and Compound Feeding

THE importance of removing from boiler feed water the mineral salts which reduce efficiency by producing a hard scale, or else of so changing these salts that they are thrown down in a form which can easily be removed from the boiler, is well recognized.

In general, 2 classes of treatments are in use: To remove the salts either by a water softening or a heat treatment process before the water enters the boiler; or by adding chemicals to the water which will result in throwing down the salt in a soft sludge inside the boiler. Of the water softening processes, there are 2 types—the intermittent and the continuous—and of the continuous there are 2 divisions, the open and closed systems. Heat treatment may be given with or without the use of chemicals, and may be either at atmospheric pressure, which without chemicals will result in removing practically all bicarbonates, or the live steam purification method, which is carried on at boiler pressure and results in removing the greater part of the sulphates.

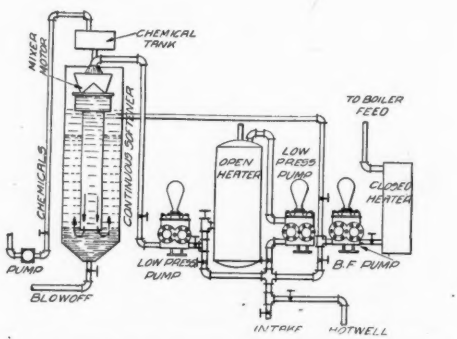



FIG. 2. PIPING FOR CONTINUOUS OPEN SOFTENER

The intermittent water softening process is usually carried on with the water cold, and in a building outside the boiler room proper, as considerable space is required. If the water be heated before treatment, the chemical action is much more rapid, and the size of the plant may be reduced correspondingly. In this method, the chemicals, in proportions required as shown by chemical analysis of the water, are introduced into the tank, and the water continually stirred for a period sufficient to permit of the full chemical action taking place. With the water cold, this takes about 3 hr.; with the water at 90 deg., 1½ hr.; at 170 deg., 1 hr., and at 220 deg. it may be completed in about 20 min.

After the reaction is completed, the water is allowed to stand quiet until the separated mineral salts, which have become insoluble, settle to the bottom of the tank. This precipitation will be rapid at first for the larger particles, and then increasingly slower for the finer particles, but in general, from 1 to 2 hr. is desirable.

Piping for such a system provides for conveying of raw water from a pump to a measuring tank, in which the chemicals are added to the water, and the whole is then dumped into the treating tank; or the raw water is pumped directly to the treating tank and a chemical solution from an overhead tank is added, the flow of this chemical being proportioned to the flow of water into the tank. At least 2 tanks are necessary, one for treating and settling, while the other is supplying the water to the boiler feed. It is best to pass the treated water through a filter before sending it to the feed pump, as this will assist in removing all precipitate. From the filter, the water passes through the open heater, which is set so as to supply water to the boiler feed pump suction under head, or it passes direct to the boiler feed pump in case the heater is not in service. As in all cases of boiler feed pump connection, there should be provision for drawing the water direct from the hot well and from another source of feed without sending it through the treating system, so that operation of the plant may be continued in case of repairs to the treating system.

In the intermittent system, if no filter is used for the treated water, it is best to take the suction of the boiler feed pump from near the top level of the water in the treated water tank, since this water near the surface will be freer from precipitate than that near the bottom. The end of the suction pipe should be carried by some float arrangement which will descend with the water level while keeping the pipe far enough beneath the surface of the water to insure a good suction. For a 1000-hp. plant, Morris gives as the size of tanks, to be changed every 8 hr., 20 ft. diameter by 14 ft., having a capacity of 32,000 gal. each.

In the continuous system, the water is mixed with a chemical at the top of a tall tank and passes slowly down through an inner tube, then rises outside this tube to the top of the tank, from which it is drawn by the boiler feed pump. In the illustration of the continuous system, Fig. 2, the chemicals are shown as being pumped to the top of the tank, and from the small tank at the top of the tower, are drawn into the raw water by means of some kind of a motor mixer, directly in proportion to the amount of raw water passing through the motor. The chemical solution is made up, in this case, on the ground level, while in the system shown for the intermittent treatment, the chemicals are raised to the top of the tanks dry and there mixed in a large tank. In the illustration of the continuous system, the boiler feed pump is shown as taking its water either direct from the intake from the open heater in case the softening system is shut down, or from the outlet of the softening system, and sends the feed water through a closed heater on the way to the boiler. The arrangement also provides for pumping water from the intake into the open heater, then from the open heater to the continuous softening plant, so that the reaction inside the softener may be more rapid.

In the closed system for continuous treatment, which is practically always a hot treating system, the solution is mixed in a tank and from that dropped to a solution tank which has a small pipe leading to the suction of an auxiliary pump connected to the raw water pump, so that the amount of solution fed is always directly in proportion to the amount of raw water pumped into the softener. Exhaust steam is frequently used in the softener, and in such case should be passed through an effective oil separator. Piping is provided for washing out the sludge from the softener tank, also for blowing off the solution and softener tanks. The raw water mixed with chemical solution passes into the softener and meets the steam jet, then trickles over a series of trays where much mineral salt is deposited; it next passes through a V-shaped chamber to the space below the filter, then rises slowly outside this V-chamber through the filter, and runs over a weir into the compartment from which the boiler feed is taken. A low-pressure safety valve should be provided to prevent accumulation of pressure in the softener.

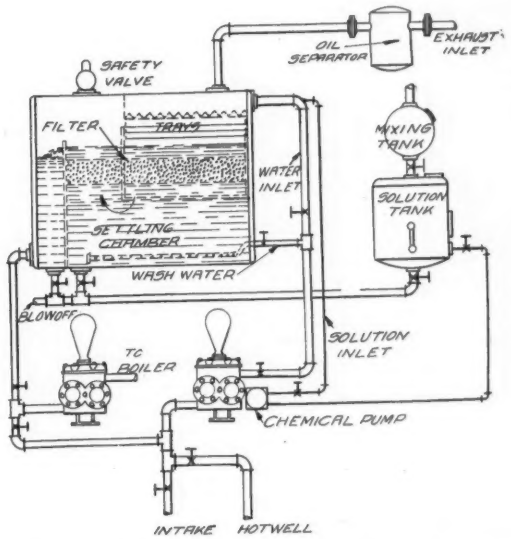



FIG. 3. HOT TREATMENT WITH CHEMICALS IN CLOSED SYSTEM

In piping up any system for water treatment, the treated water should not be sent through long lines of pipe after the chemicals are added to the water, especially if the water is hot, as this will result in a rapid filling up of the pipe lines.

### Compound Feeding

When using a boiler compound, the feed should be as nearly continuous as possible. In some instances, this is inconvenient and the intermittent method of feeding must be adopted; but in such case, a comparatively small amount should be fed in frequently. The compound in liquid form may be drawn with the feed water into the suction pipe of the feed pump. In most cases this will be satisfactory; but in some instances the chemicals in the compound may act upon the valves and packing of

the pump so as to corrode them rapidly. In any case, if the pump is situated far from the boiler, it is better to arrange to have the compound fed into the feed water line as near to the boiler as possible to avoid clogging of the feed lines by scale.

Several devices for feeding compound are illustrated herewith, A being a method for feeding to the suction of the pump, B for intermittent feeding between the pump and the boiler, and C for continuous feeding close to the boiler.

### Heat Purification

When water is heated to approximately 200 deg., the carbonic acid of the water is thrown out of solution and this reduces the bicarbonates of lime and magnesia to monocarbonates, which are insoluble, so that these salts will be thrown down. This may be accomplished in any open heater and purifier, using exhaust steam only, if the amount is sufficient to bring the water to the desired temperature; if not, a slight amount of live steam must be used, passed through a reducing valve. The removal of the salts is by precipitation and filtration, as shown in the closed system of Fig. 3; but the method may be used without the addition of chemicals. If sulphates are to be removed, chemical treatment must be added to the heat treatment. Another advantage of this treatment is that the heating of the water permits the dissolved air also to escape, which tends to cut down corrosion in the boiler.

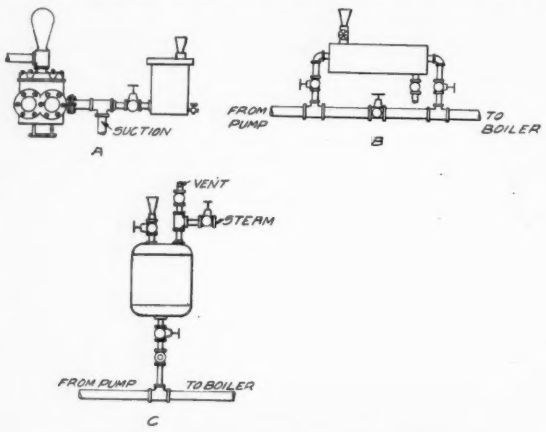



FIG. 4. METHODS OF FEEDING COMPOUND

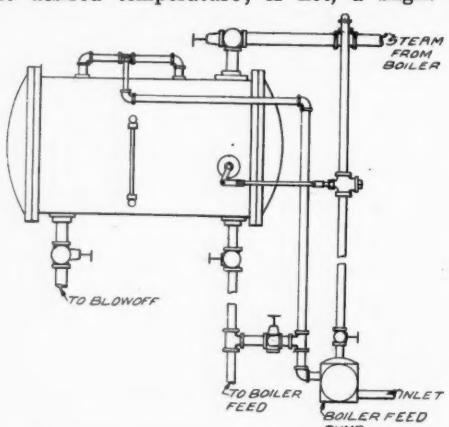



FIG. 5. PIPING FOR LIVE STEAM PURIFIER

Sulphates may be largely removed by heating to boiler temperature in a live steam purifier. In this, the water is pumped in at the top and passes down over a series of trays, running over the edges of these trays and along the bottoms in a thin sheet, then falling to the next tray below in the series. At temperatures around 300 deg. F., the sulphates tend to separate out and attach themselves to the surfaces of the trays, which are arranged to be removed from the purifier and cleaned at intervals as needed. Direct connection is made to the purifier from the steam space of the boiler, so that full boiler pressure is carried, and the purifier should be so set that the water will flow from it to the boiler by gravity. This means that there must be sufficient water head between the purifier and boiler to overcome the friction in piping and valves, as well as the drop in steam pressure between the boiler and the purifier. Morris suggests that in most cases 8 ft., if possible, is desirable head to provide. The friction to be overcome in the piping should be determined on the basis of 3 times the amount of water required for supplying the boiler at rated capacity, flowing from the purifier to the boiler continuously.

By this arrangement, only one boiler feed pump is required, as this can be used to pump the water into the purifier, or by means of a bypass to pump direct to the boiler when the purifier is out of use. The water in the purifier should stand at not more than half the height of the purifier, and a float should be arranged in each purifier controlling, in the case of a single purifier, the steam supply to the boiler feed pump, or in the case of several purifiers, the water supply to the purifier; the speed of the pump then being controlled by a pressure regulator which keeps the pressure in the feed main to the purifiers constant. Connection must, of course, be provided at the bottom of the purifier for blowing out sediment and dirty water, and a gage glass should be attached which will show the height of the water in the purifier.

# Hot Water Heating

### Systems Employed and Their Connections

HEATING systems employing water as the circulating medium may be divided into 2 classes: (a) the open or low-pressure system which, due to its ease of management and temperature regulation, is particularly suitable for dwellings, schools, offices, etc., and (b) the sealed or high-pressure system used largely for industrial purposes, such as drying rooms, boiling pans, ovens, etc. On account of the higher temperature realized in the sealed system as compared with the open system, a smaller quantity of heating surface is necessary, smaller pipes may be used and in consequence the initial cost is less.

Circulation is maintained due to the temperature difference between the supply and return risers, although where difficult conditions are to be overcome, it may be necessary to accelerate this natural circulation by the injection of steam into the flow main. Forced circula-

tion, by means of centrifugal or rotary pumps, is frequently employed in tall office buildings or where the saving due to the use of smaller pipe will pay for the cost of pumping.

There are 3 general systems of piping in use for connecting the heater to the riser. In the 2-pipe system shown at A, Fig. 1, supply and return mains are carried parallel to one another, the former decreasing in

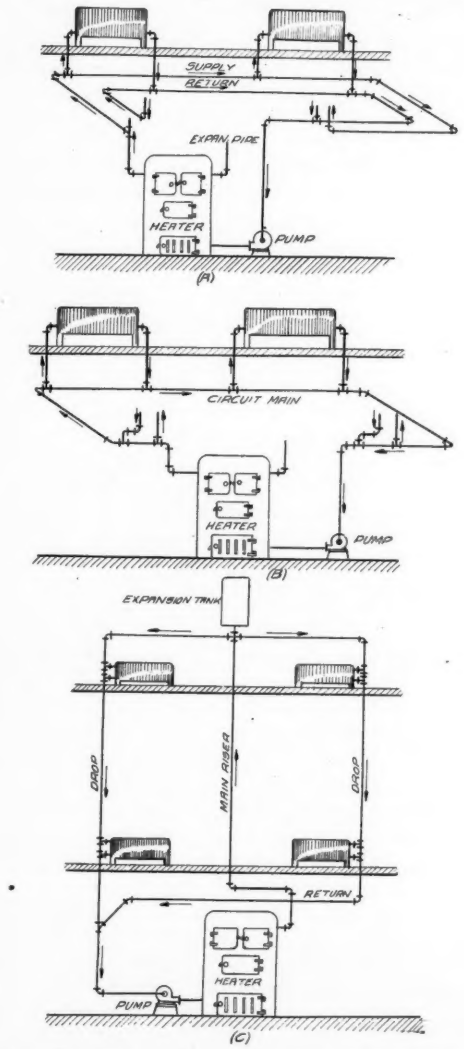



FIG. 1. COMMONLY-EMPLOYED SYSTEMS OF HEATER-TO-RISER CONNECTIONS

size and the latter increasing as the risers are taken off.

As the difference in pressure between the supply and return mains is greater nearer the heater than at the end of the line, throttling valves must be provided in the risers for equalizing the flow through all parts of the system.

In the circuit system, B, Fig. 1, a single main of uniform size is carried entirely around the building, extending from the pump discharge back to the suction inlet. Supply risers are taken from the top of the main and the corresponding returns are connected into the side of the main, a distance of 6 or 8 ft. farther along the line.

The overhead system of distribution shown at C, Fig. 1, is especially adapted to office buildings. The main riser is carried directly to the top of the building, where it branches and connects with the top of the supply drops as shown; the return from the radiators in this case goes back into the same pipe.

Supply and return risers for the circuit system may be of the same size as those for gravity circulation, and those for the 2-pipe and down-feed systems, one size smaller. Under ordinary conditions, about 1.2 gal. of water a minute should pass through the main for each 100 sq. ft. of direct radiation to be supplied.

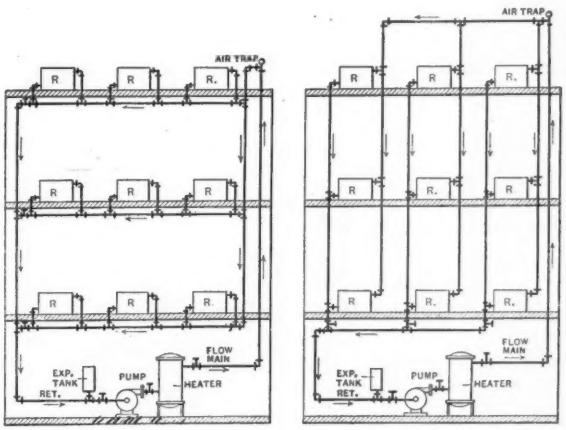



FIG. 2. RADIATOR CONNECTIONS FOR HOT-WATER HEATING SYSTEMS

The following table gives the capacities of pipes of different sizes for velocities of flow commonly employed. These vary under ordinary conditions from 300 to 600 ft. a minute, according to the size of the main.

CAPACITIES OF PIPES FOR HOT WATER

| Size of main, in..... | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|
| Capacity, gal. per min..... | 100 | 250 | 400 | 700 | 1000 | 1500 |

Two of the most commonly employed methods of radiator feed are shown in Fig. 2. In the first a circuit main is carried around the basement, connecting both supply and return risers into the same pipe, as at B, Fig. 1, and depending upon the difference in pressure, between the points of connection to establish flow through the radiators.

With the second arrangement shown in Fig. 2, known as the 2-pipe system, this cooling effect is entirely eliminated by having the individual radiator discharge pass directly into the return instead of entering any of the others; it also allows forcing the water through the system at a greater velocity and thereby increases its capacity.

SIZES OF MAINS

SIZE of the main is fixed by the allowable velocity of flow through it and the frictional resistance due to its length and number of bends.

In the arrangement shown at B, Fig. 1, length of main and number of bends are easily determined, and the size is made the same throughout. No allowance is made for frictional resistance through risers and radiators, as this is practically cared for by the temperature difference in the 2 risers, assisted by the drop in pressure in the main between supply and return connections.

In the 2-pipe system it is customary to assume that conditions are the same as if the water flowed through the circuit in a single pipe of uniform size instead of 2, one of which is constantly increasing in size and the other decreasing.

In the case of C, Fig. 1, it is assumed to be the same as if the main were kept of uniform size and first carried to the extreme end of the basement, then to the attic, across to the other end of the building, down to the basement and back to the pump.

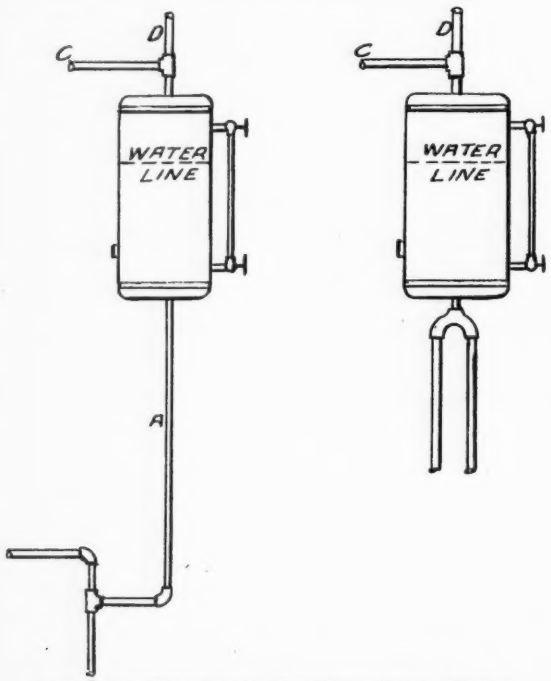



FIG. 3. PROPER EXPANSION TANK CONNECTIONS

In work of this kind, it is customary to base the size of main on an assumed velocity which may be taken as 300 ft. per minute for a 3-in. pipe, up to 600 ft. for an 8-in. pipe.

The pressure head pumped against is simply that required to overcome the friction in the pipe, as all vertical runs are in equilibrium except for differences in temperature, which tend to increase the flow.

In the average building, the length of main will not usually exceed 1000 ft., which, for the figures given in this table, will call for pressure heads ranging from 34 to 47 ft.

For groups of buildings where the length of run exceeds 1500 ft., complete tables should be consulted which may be found in any engineers' pocketbook on hydraulics.

From a table of hydraulic data referring to the flow of water through pipes of different sizes, we have the following:

CAPACITIES OF MAINS

| Dia. of Main, Inches | Velocity of Flow in Feet per Minute | Gallons Discharged per Minute |
|---|---|---|
| 3 | 300 | 110 |
| 4 | 420 | 275 |
| 5 | 420 | 428 |
| 6 | 480 | 705 |
| 7 | 540 | 1079 |
| 8 | 600 | 1566 |

Sizes of supply and return risers between basement mains and radiators, in the systems shown in A and B, Fig. 1 may be taken as follows:

CAPACITY OF HOT WATER RISERS

| Dia. Supply and Return Inches | Sq. Ft. Radiation Supplied |
|---|---|
| ¾ | 50 |
| 1 | 100 |
| 1¼ | 200 |
| 1½ | 300 |
| 2 | 600 |
| 2½ | 1200 |
| 3 | 2000 |

With the upward feed, 2-pipe and circuit systems, the risers may be reduced every 2 or 3 stories upward, keeping the sizes just sufficient to supply the radiation above them. With the down-supply, single-drop system, the values given in this table may also be used; but in this case, the pipe must be kept the same size for its entire length, and must be proportioned for the total amount of radiation supplied by it.

EXPANSION TANKS

EXPANSION TANKS should be placed at the highest point of the system, accessible and in open view at all times, and must be protected from frost. Open tanks should have a capacity equal to about 5 per cent of that of the system, while the size of closed tanks depends upon the maximum temperature at which the water is to be maintained. Where this is 300 deg. F., the tank capacity should be 10 per cent of that of the system; for 400 deg. F., 16 per cent; and for 500 deg. F., 75 per cent of that of the entire system.

In the tank connections shown at the left, Fig. 3, supply line A is taken from return pipe. Overflow C should be carried to a closet tank or other open fixture and should be provided with a vent D extending no less than 6 in. above the connecting tee. With the connections shown at the right, the water is caused to circulate within the tank to prevent freezing and the supply and return pipes are taken from the risers below the floor in order that the tank may interfere as little as possible with the proper working of the radiator.

If desired, makeup may be introduced into the system through the expansion tank by means of a float valve.

CAPACITIES OF EXPANSION TANKS

| Size, Inches | Capacity Gallons | Sq. Ft. of Radiation | Size, Inches | Capacity Gallons | Sq. Ft. of Radiation |
|---|---|---|---|---|---|
| 10x20 | 8 | 250 | 16x36 | 32 | 1300 |
| 12x20 | 10 | 300 | 16x48 | 42 | 2000 |
| 12x30 | 15 | 500 | 18x60 | 66 | 3000 |
| 14x30 | 20 | 700 | 20x60 | 82 | 5000 |
| 16x30 | 26 | 950 | 22x60 | 100 | 6000 |

# Special Services

## Water Piping for Various Services About the Power Plant

IN Fig. 1 is shown a simple starting arrangement for a service pump that connects with a line which is always filled with water. Pipe lines A can be turned on and valve B opened to furnish an outlet for air (and water also in starting) with stop valve C closed; the pump being protected against excess pressure by relief valve D, can then be started without difficulty. The lines A are the priming pipes and may be connected to any water supply, as pressure is not required. As a rule, the priming line to a pump has a diameter of about ⅛ that of the pump suction.

If priming water is not readily obtainable, or if a pump of the centrifugal type is used, a satisfactory foot valve may be built as shown in Fig. 2. With the valve so constructed, if the pump is to be shut down, the valve can be lowered so that it will bear on its seat and operate the same as the more common types of foot valves.

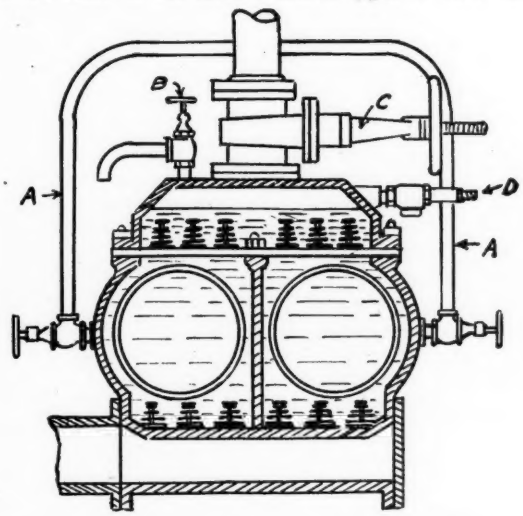



FIG. 1. PIPING ARRANGEMENT FOR STARTING A SERVICE PUMP

While the pump is in operation the valves can be raised clear of its seat, and when the pump is not in service the valve can be tightly closed.

A fire pump should have a foot valve, also a priming connection between the suction and discharge valves at both ends of the pump and should also have priming connections to the suction line. By the aid of these several details, air may be removed from the pump before it is started. If priming water is not easily obtainable from a low-pressure line or from a pump discharge as shown in Fig. 1, a hose valve should be attached to the pump between the suction and discharge valves at all 4 ends of a double-acting pump. This detail can be satisfactorily arranged by connecting the 4 ends with piping and employing check valves that open into the ends of the cylinders and a stop valve to control the water from the hose or pipe line.

### Damper Regulation

In general, the hydraulic damper regulator requires a pressure line from the bottom of the steam header, a water line to the controlling valve that admits water to the plunger, and a waste water line from this controlling valve to relieve pressure on the ram.

Figure 3 shows a typical hydraulic damper regulator installation. The steam connection from the boiler to the regulator which is made of ¼-in. brass pipe should be taken from some point where the pressure is steady

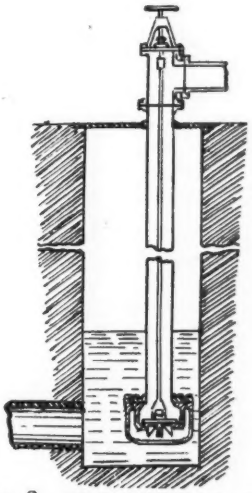


FIG. 2. FOOT VALVE FOR PUMP

and is not affected by another pipe. A valve should be placed near the regulator in this small steam connection pipe to shut off steam from the regulator when necessary. The water pressure connection, which is also made of ¼-in. brass pipe, may be connected to the city pressure or to some tank located not less than 45 ft. above the regulator.

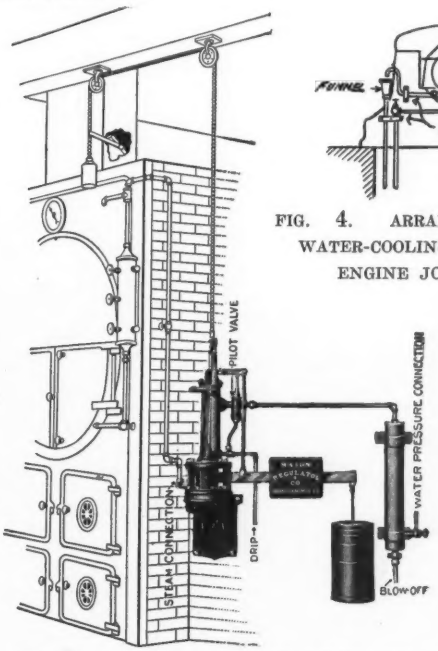



FIG. 3. HYDRAULIC DAMPER REGULATOR CONNECTIONS

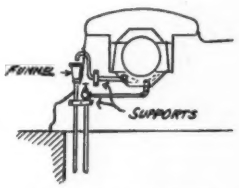



FIG. 4. ARRANGEMENT OF WATER-COOLING PIPES FOR ENGINE JOURNALS

When a tank or city pressure is not available, the water pressure may be taken from the boiler from a point below the water line. In this case, a large settling chamber 5 or 6 in. in diameter by 5 or 6 ft. high

with a blowoff valve in the bottom, should be placed between the boiler and the regulator to allow the sediment to settle where it may be blown out daily, and to furnish a cool supply, as hot water has a destructive effect on the leather packing of the regulator. The inlet pipe to the sediment chamber should enter about 2 ft. from the bottom and the connection to the regulator should be taken from the top. For convenience, the water supply connections have a small shut-off valve placed at the inlet to the sediment chamber. The drip pipe should be connected to some waste pipe in which there is no back pressure.

### Cooling Engine Journals

Many large engines are provided with hollow journal shells and provision is made to pass water through these chambers to carry off the heat generated by friction. In common practice, the lower sections of the main journals are the only bearings that are water cooled, as they lie in close contact with the shaft at all times, thus preventing a free supply of oil to their sliding faces.

In designing a water-cooling system for journals, provision should be made so that the pipe connections will be free to expand and contract at the connections with the journal. This allowance is not made on account of heat, but because of the movement of the lower shell. If the side cheeks are quite free from the shaft, it will move crosswise in the bearing and cause the bearing to move also. This movement cannot be taken up entirely or the journal will heat. Some pounding is bound to occur in the journal, and as this continual jar is apt to break pipe connections, it is advisable to make the nipple, and possibly the next piece of pipe away from the journal extra heavy. If the opening in the journal is large, it will be found advisable to reduce the diameter of the pipe at the first elbow to a size smaller than the regular line to the journal.

In Fig. 4 is shown a satisfactory construction with the pipe connections entirely outside of the frame, thus avoiding the possibility of their being strained against the frame of the engine. They are exposed to view, which is of advantage in case of leaks. The water can be diverted over the surface of the journal either by means of directing partitions cast in the journal or by a pipe run into the journal and forming one of the connections. A regulating valve is placed on the inlet branch, the outlet being free to atmosphere and discharging into a funnel in order that the flow may be readily observed by the operator. To allow maximum flexibility, the piping supports should be well away from the journal. The discharge should be carried to a height slightly above the journal, thus insuring that the bearing will at all times be filled with water.

City water instead of the regular station water should be employed for cooling journals if the station water is too warm to be effective. Rather than use city water, however, it is often more economical to use a greater amount of station water. If city water is used exclusively, it should be discharged into a drip main so located that the water will drain into the heater. Funnels should be fitted so that the drip flow may be observed and if the heater is located too high to permit the use of a gravity discharge, the sights may be made air-tight, thus permitting a back pressure on the engine journals, sights, and line. To avoid the loss of air confined in the glass body such sight should be placed where there is the least pressure.

# Steam Piping

### Arrangement of Mains and Headers; Branch Connections; Valves Required

WHERE LEADS CONNECTING BOILERS and steam headers are made up of vertical and horizontal runs, long-turn bends should be used instead of ells, and when of considerable length, the scheme illustrated at C, Fig. 1, is preferable in order to avoid vibration and to keep the weight of the pipe along a line drawn through its supports. For high-pressure saturated steam, steel piping and cast-iron fittings are used; if superheat is employed, only cast-steel valves and fittings will withstand the high temperatures encountered. For pressures up to 125 lb. per sq. in., standard fittings are applicable; above 125 lb., extra-heavy fittings must be employed.

All boilers must be provided with a stop valve of the gate or globe type, and except in single-unit installations the use of some form of automatic non-return valve placed between the main valve and the boiler is recommended. This should be located at the highest point of the lead and as near the header as possible.

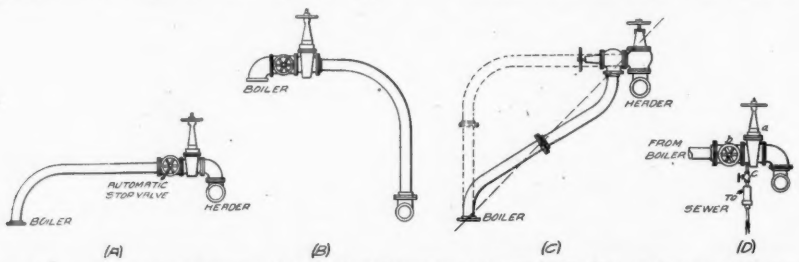



FIG. 1. TYPICAL BOILER BRANCH CONNECTIONS AND PROPER LOCATION OF VALVES

Placing the 2 valves as shown at D, Fig. 1, the automatic valve can be taken apart while the header is in operation.

To avoid the collection of water around the stuffing box, steam valves should not be placed with stems downward, and where impossible to place the valves as to be accessible from the top of the boiler, the floor or a gallery, bevel bearing and rod, or an endless chain may be employed. In many large plants these valves are remotely controlled by means of electric motors, air, steam or water pressure.

When specifying valves for superheated steam, care should be taken that no soft composition is used. In a globe valve the disc, seat, and that part of the stuffing-box gland coming in contact with steam, should be made of gun metal, nickel steel, or other hard alloy. The same may be said in regard to gate, seat and gland of a gate valve.

Nonreturn valves as used on boiler leads are primarily check valves fitted with a stem and hand wheel, allowing them to be operated the same as an ordinary globe or gate valve, and so constructed that with a reversal of steam flow the disc will seat and shut off further flow of steam. Cushioning is provided by means of a piston working in a dashpot or a spring located either externally or internally as shown in the accompanying sectional views of commercial types.

An added feature of some of these valves is the arrangement employed by means of which they may be closed when a reduction of pressure occurs beyond the main stop valve, as in the case of a header failure. The reduction in header pressure acting on a pilot valve causes this to open and admit steam taken from the boiler to the top of a piston above the disc of the automatic valve. This, having an area greater than that of the disc, forces the disc down on its seat, thereby shutting off the flow of steam. When normal header pressure is again established, the pressure above this piston is released and the valve allowed to open.

### Headers

Engines or turbines may be connected to the boilers feeding them by means of the single header, the loop or ring header, or the unit system, the method employed depending largely upon local conditions and requirements.

Due to its simplicity, low first cost and provision for expansion, the single header is well adapted to small plants, although if any section of such a header must be cut out, it will interfere to some extent with the operation of the plant.

The loop header finds its widest application in installations in which a large number of engines and pumps are crowded together in a comparatively small space. Sectionalizing valves in the main and cross-connections allow any section to be isolated for repairs.

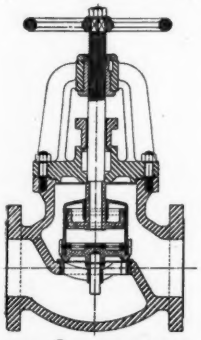


FIG. 2. SECTIONAL VIEW EDWARD NON-RETURN VALVE

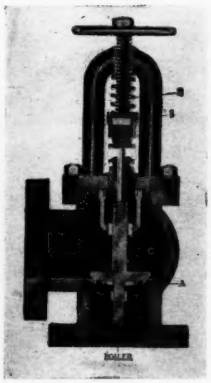


FIG. 3. FORD AUTOMATIC EMERGENCY RETURN CHECK AND STOP VALVE

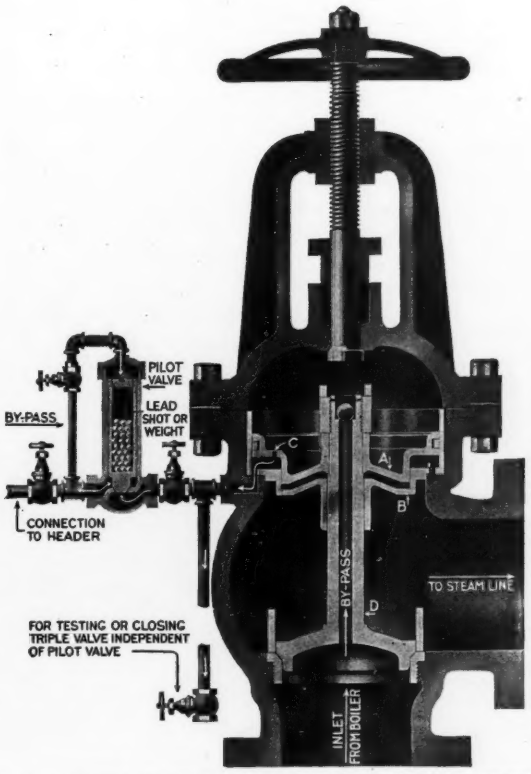



FIG. 4. GOLDEN-ANDERSON TRIPLE-ACTING DOUBLE-CUSHION NON-RETURN GLOBE VALVE

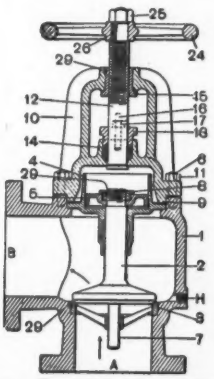


FIG. 5. FOSTER AUTOMATIC NON-RETURN STOP VALVE

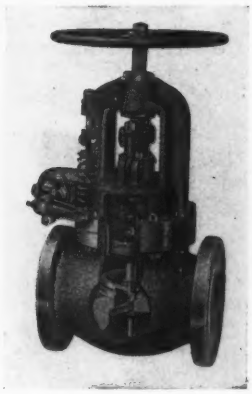


FIG. 6. LUNKENHEIMER NON-RETURN SAFETY BOILER STOP VALVE

In large power stations, the tendency is to employ the unit system, in which each prime mover is supplied by its individual group of boilers; the various units are tied together, however, by equalizer pipes so that there is in reality a header of diminished capacity between them.

### Auxiliary Mains and Cross Connections

Auxiliary mains should be installed at sufficient distance from the steam header to allow for expansion and contraction in the case of one being cold and the other hot, and should be pitched in the same direction as the flow of steam with provision for drainage.

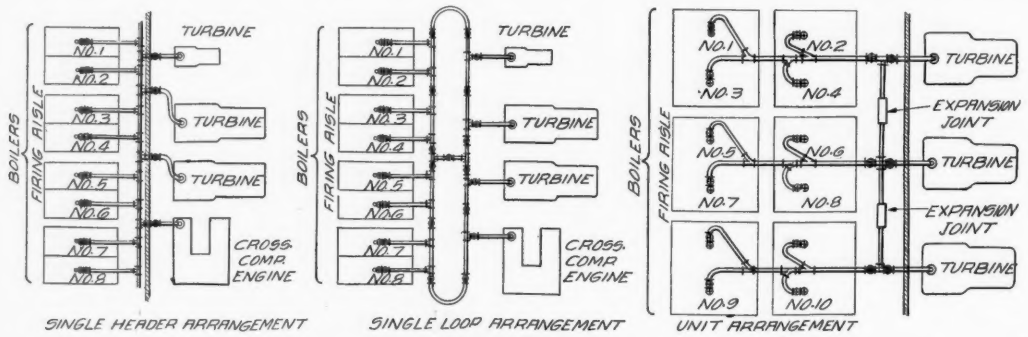



FIG. 12. SINGLE HEADER, SINGLE LOOP AND UNIT ARRANGE MENT OF STEAM MAINS

Present-day designers regard the function of the header as that of an equalizer rather than a storage reservoir, and make the header the same size as that of the largest connecting branch pipe. In such an arrangement, receiver-type separators having a volume of from 2 to 4 times that of the high-pressure cylinder are installed as near the throttle valve as possible. The use of such separators provides a full supply of steam close to the throttle, makes possible much smaller header and branch connections (thereby greatly reducing the cost of the piping system throughout) insures drier steam to the engine and reduces radiation losses.

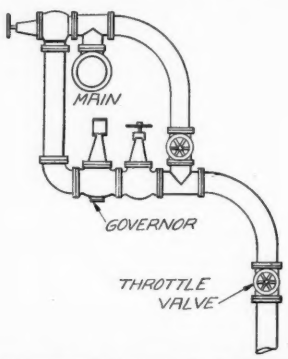



FIG. 13. TYPICAL PUMP BRANCH CONNECTION TO AUXILIARY MAIN

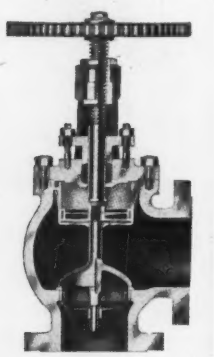


FIG. 7. JENKINS AUTOMATIC EQUALIZING STOP AND CHECK VALVE

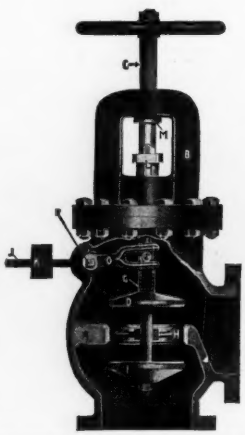


FIG. 9. LAGONDA ANGLE-TYPE AUTOMATIC CUT-OFF VALVE

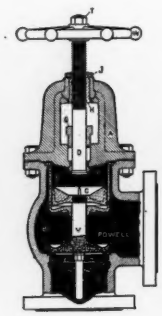


FIG. 8. POWELL WHITE STAR AUTOMATIC NON-RETURN BOILER VALVE

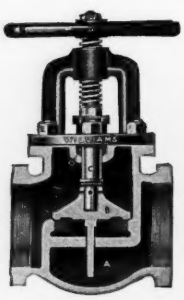


FIG. 10. WILLIAMS BRASS REGULATING STOP CHECK VALVE

FIG. 11. CRANE-ERWOOD AUTOMATIC DOUBLE-ACTING NON-RETURN EMERGENCY CUT-OUT VALVE

Like the boiler leads, headers carrying high-pressure saturated steam should be made up of steel piping with cast-iron fittings; for superheat, use only cast-steel valves and fittings.

If, in the installation of steam headers, the formation of pockets cannot be avoided, provision should be made for drainage by means of traps which should at all times be maintained in proper working order.

Preferably, steam should be taken out of the top of the main, and by keeping the main well drained, any auxiliary apparatus may be started immediately and be not liable to delay due to the auxiliary cylinder filling with condensation.

Cross connections which of necessity are generally of comparatively short length, must be provided with means to compensate for the effects of expansion and

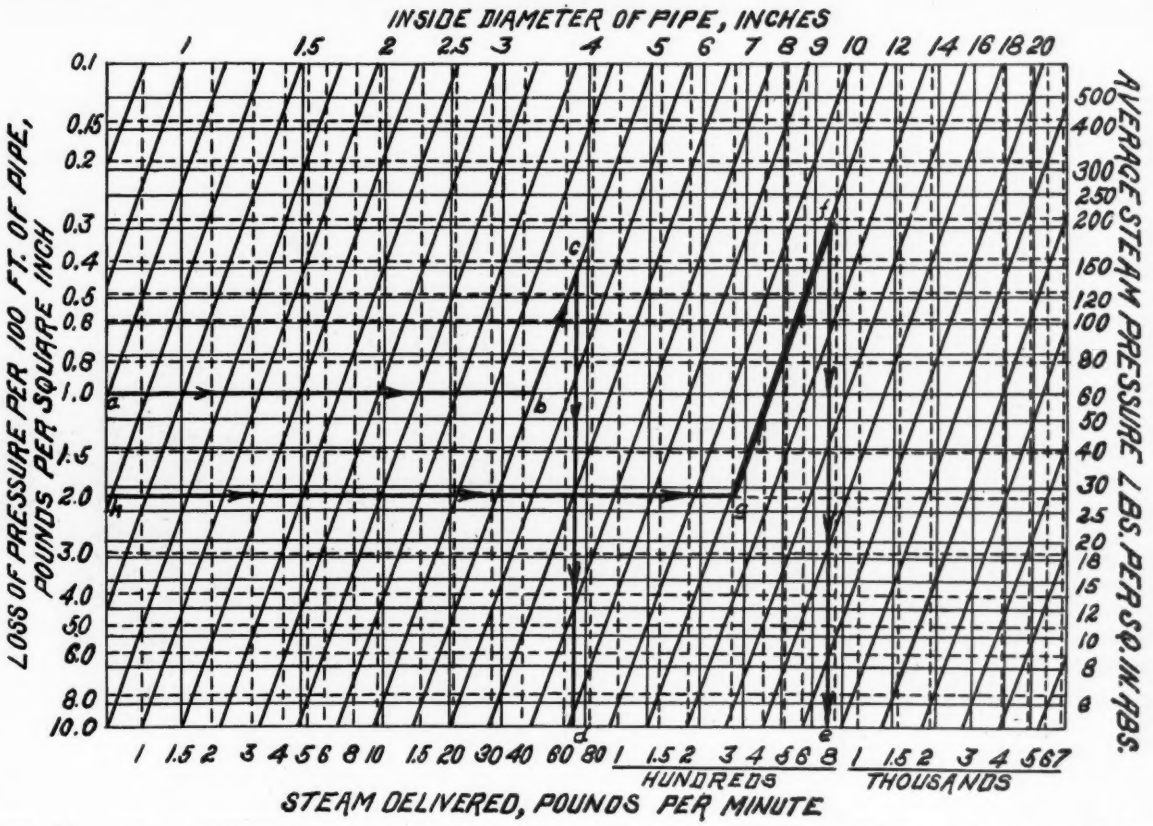

INSIDE DIAMETER OF PIPE, INCHES
1 1.5 2 2.5 3 4 5 6 7 8 9 10 12 14 16 18 20
LOSS OF PRESSURE PER 100 FT. OF PIPE, POUNDS PER SQUARE INCH
0.1 0.15 0.2 0.3 0.4 0.5 0.6 0.8 1.0 1.5 2.0 3.0 4.0 5.0 6.0 8.0 10.0
AVERAGE STEAM PRESSURE LBS. PER SQ. IN. ABS.
500 400 300 250 200 150 120 100 80 60 50 40 30 25 20 18 15 12 10 8 6
a b c d e f g h
1 1.5 2 3 4 5 6 8 10 15 20 30 40 60 80 1 1.5 2 3 4 5 6 8 1 1.5 2 3 4 5 6 7
HUNDREDS
THOUSANDS
STEAM DELIVERED, POUNDS PER MINUTE

FIG. 14. LOSS OF PRESSURE WHEN A GIVEN AMOUNT OF STEAM IS DELIVERED THROUGH A PIPE OF GIVEN SIZE

contraction; and for flexibility of operation, it is desirable that they contain some form of cutoff valve in addition to a valve on each side of the tee where they join the mains.

Stop valves placed next to the main should be used on all auxiliary branches in addition to the throttle valve. This should always be a globe or an angle valve and should be so arranged as to be accessible for repairs after closing the stop valve. Shown in Fig. 13 is an auxiliary main for pump connection with an opening at the top, and the steam governor, valves and bypass placed so as to have their weight carried by the main.

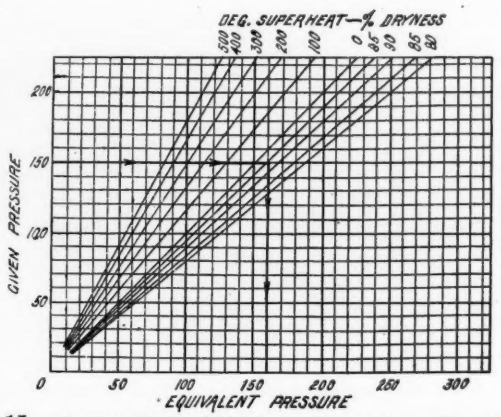



FIG. 15. EQUIVALENT PRESSURES OF WET AND SUPERHEATED STEAM

### Flow of Steam in Pipes

In determining the size of a main for moderately superheated steam under pressures ranging from 125 to 150 lb. per sq. in., a velocity of from 6000 to 8000 ft. per min. is generally assumed as standard practice, although velocities as high as 12,000 ft. per min. are permissible if the pipe is less than 50 ft. long and free from sharp bends. In recent installations of large size turbines, the great volume of steam delivered to the machines necessitates the use of velocities up to 20,000 ft. per min. For exhaust lines, 4000 ft. per min. is a safe working figure.

By means of the chart, Showing Loss of Pressure When a Given Weight of Steam per Minute is Delivered Through a Pipe of Given Size, by Prof. H. V. Carpenter, and based upon the most commonly accepted formula* for the flow of steam through pipe, the relation between size of pipe, average pressure, drop in pressure, and weight of steam passing in pounds per minute may be determined. To obtain the pressure drops for lengths other than 100 ft., multiply by lengths in feet and divide the product by 100.

Let it be desired to determine number of pounds of steam which may be delivered per minute by a 100-ft.

* $$W = 87.5\sqrt{\frac{f\,g\,d^5}{L\left(1+\frac{3.6}{d}\right)}}$$

Where f = fall in pressure from entrance to exit, in pounds per square inch.
g = mean density of steam, in pounds per cubic foot.
d = diameter of pipe, in inches.
L = length of pipe, in feet.
K = coefficient, given by Carpenter and Unwin as 87.5.

length of 5-in. pipe, at a pressure of 150 lb. per sq. in., absolute, and with 1 lb. drop.

Follow the 1-lb. drop line, (ab), over to the 5-in. pipe line, then, (bc), up to the 150-lb. pressure line, and thence down, (cd), to Steam Delivered, Pounds per Minute, approximately 66 lb.

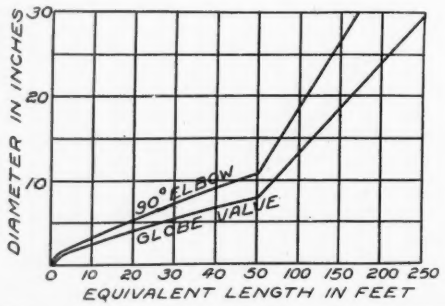



FIG. 16. LENGTH OF PIPE EQUIVALENT TO FITTINGS

A turbine rated at 2000 kw. has a guaranteed steam consumption of 15 lb. per kw.-hr. under a pressure of 200 lb. per sq. in., absolute. Determine the size of pipe required to supply this machine with steam, if it is to be operated at 150 per cent load and is located 150 ft. from the steam supply; allowing a drop of 3 lb.

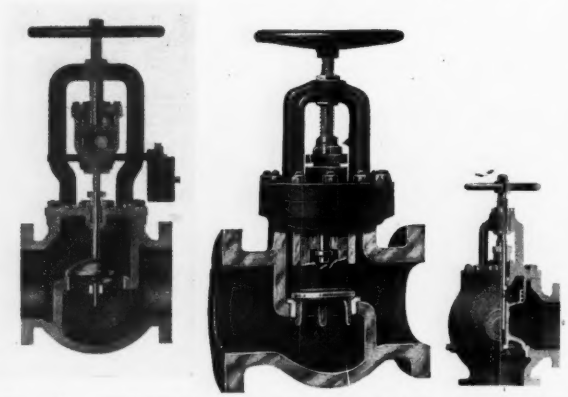


FIG. 17. SECTIONAL VIEW OF DAVIS CLASS C AUTOMATIC CHECK AND STOP VALVE

FIG. 18. ACTON AUTOMATIC NON-RETURN STOP AND CHECK VALVE

FIG. 21. SCHUTTE AUTOMATIC NOISELESS STOP CHECK VALVE

At maximum load, the total steam required is equal to $1.5 \times 2000 \times 15$, or 45,000 lb. per hr., or 750 lb. per min. From this point on the chart follow upward (ef) to the intersection of the 200-lb. pressure line; then (fg) parallel to the 12-in. pipe line until it intersects hg. (The allowable pressure drop being 3 lb. for 150 ft. is equivalent to 2 lb. for 100 ft.)

From the pipe sizes directly above the intersection of hg and fg read 6⅔ in. as the required size of pipe. We would, therefore, select a 7-in. pipe.

---

For standard 90-deg. elbows $L = 76d \div \left(1 + \frac{3.6}{d}\right)$

For globe valves $L = 114d \div \left(1 + \frac{3.6}{d}\right)$

Where L = length of pipe in inches and d its diameter, also expressed in inches.

### Wet and Superheated Steam

For wet steam we must use in the diagram, instead of the given pressure, an equivalent pressure, or the pressure of dry steam, which would have the same density as the wet steam at the given pressure. In a like manner, for superheated steam, we must employ the equivalent pressure at which dry steam would have the same density as the superheated steam at the given pressure.

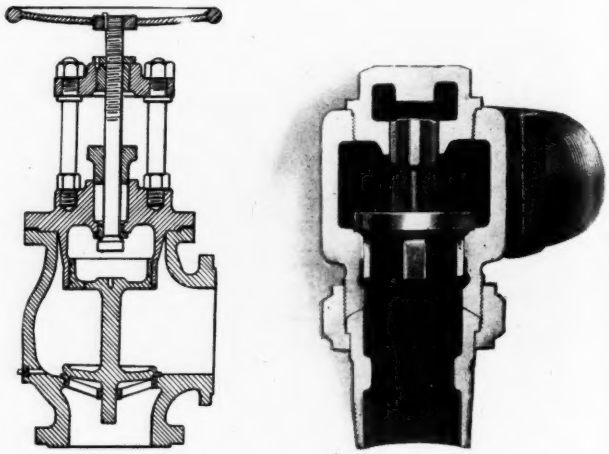


FIG. 19. SECTION NELSON AUTOMATIC NON-RETURN STOP AND CHECK VALVE

FIG. 20. HANDCOCK MAIN CHECK VALVE

These corrections may be made by means of the conversion charts shown in Fig. 15. Wet steam at 150 lb. pressure and 95 per cent dryness is equivalent to saturated steam at 160 lb. pressure; steam at a pressure of 150 lb. and superheated 200 deg. F. is equivalent to approximately 112 lb. pressure of saturated steam.

### Effects of Valves and Fittings

Drop in pressure due to the resistance offered by valves and fittings is usually allowed for by treating each valve and fitting as an additional length of pipe which expressed in inches may be found according to the formula of Briggs* as follows: For 90 deg. standard elbows divide (the product of 76 times the diameter of the pipe in inches), by the sum of (1 plus the quotient of 3.6 divided by the diameter of the pipe inches). For globe valves, use 114 instead of 76.

Gate valves offer practically no resistance.

Referring to Fig. 16, we find that a 15-in. globe valve is equivalent to adding 120 ft. to the length of the pipe, and that the resistance offered by a 15-in. standard 90-deg. elbow is about ther same as that of a 27-ft. length of pipe of like size.

### Draining Apparatus

Water may gain admission to steam pipes in a number of different ways. The most obvious source, perhaps, is the condensation of steam that takes place in the pipes, on account of insufficient or improper insulation, or from admitting steam to cold pipes.

In high-pressure piping, water is dangerous. If carried into the engine cylinders in considerable quantities, it is liable to wreck the engine, or at least rupture the cylinder heads. Condensation in the mains is likely to produce water hammer, which in turn causes vibrations tending to loosen the joints.

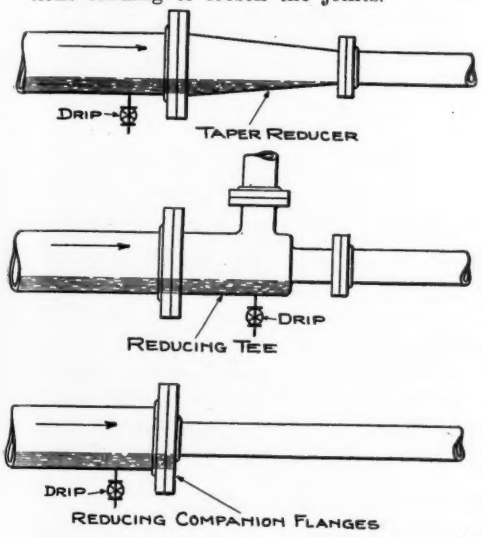



FIG. 22. LOCATION OF DRIPS AT REDUCING FITTINGS

Piping should be erected, if possible, so as to avoid pockets where water may collect; but wherever such pockets cannot be avoided and at points where risers are connected, drain pipes of ample capacity should be provided. Where small branch pipes are connected with steam mains by reducing tees, in such a way that the steam flows from the main into the branch pipes, and also when taper reducers are employed, drips should be connected at the lowest points, as shown in Fig. 22.

To drain the condensation from a horizontal run of pipe, the simple form of drip receiver shown in Fig. 23 may be employed. This consists of a short length of pipe with a blind flange at the lower end through which the drip pipe is connected. A gage glass is provided to indicate the amount of water present in the receiver.

### Separators

Separators or "water catchers" are widely employed to prevent water from gaining entrance to turbines and to cylinders of reciprocating engines, where its pressure is likely to cause damage. In order to secure the best results, the separator should be located as near the engine cylinder as possible, because if there is any considerable length of pipe between them, there will be opportunity for further condensation and the steam will again become moist. It is also desirable to have a separator of large size, or of the "receiver" type, because in this way a steam-storage reservoir is provided which insures greater uniformity of pressure in the engine cylinder up to the point of cutoff, and overcomes in large measure the vibrations in the steam piping due to the interruptions of the flow of steam from the regular and frequent opening and closing of the engine valves. Receiver separators commonly have a volume 3 or 4 times that of the high-pressure cylinder.

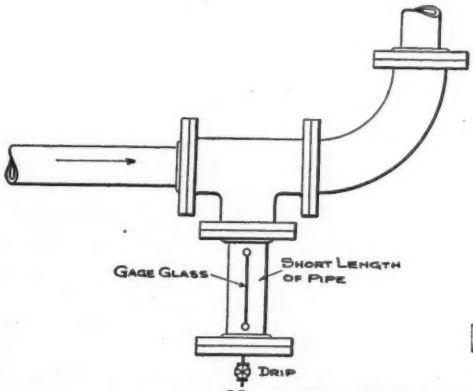



FIG. 23. SIMPLE FORM OF DRIP RECEIVER

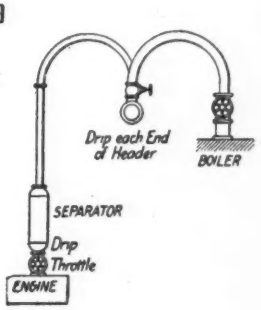



FIG. 24. DRIP ARRANGEMENT FOR ENGINE PIPING

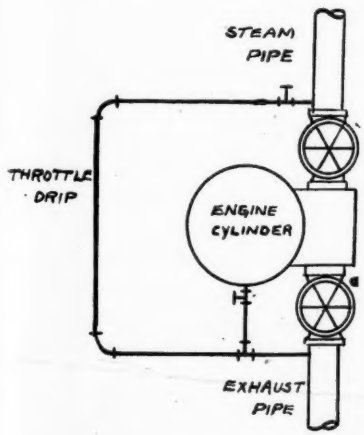



FIG. 25. ENGINE THROTTLE AND CYLINDER DRIPS

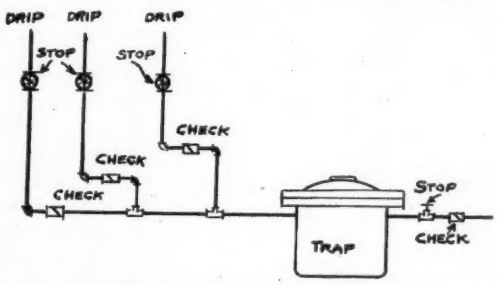



FIG. 26. DRIP PIPES CONNECTING TO SAME TRAP

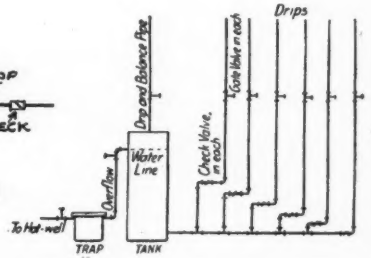



FIG. 27. ARRANGEMENT OF DRIP RECEIVER PIPING

In Fig. 24 is shown a typical arrangement of piping between the boiler and the engine in which a drip should be placed at each separator and also at each end of the main header. Where the separator is placed some distance from the engine, a common arrangement of throttle and cylinder drips is shown in Fig. 25.

In the case of separators, the size of drip pipes is usually fixed by the outlet as determined by the manufacturer. For main headers, the drip pipes are from

¾ to 1 in., while throttle and cylinder drips are commonly given a uniform diameter of ½ in. Drip piping is not expected to care for any sudden rush of water, hence there is no advantage in making it of large size.

Ordinarily, condensation from high-pressure drips is trapped to a receiving tank or hot well, from which it is pumped back to the boilers.

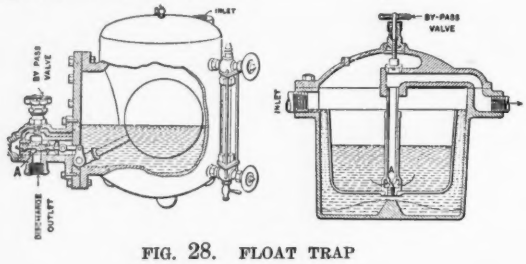



FIG. 28. FLOAT TRAP
FIG. 29. BUCKET TRAP

Where the drips are widely separated, individual traps should be provided, as there is likely to be sufficient difference in pressure to cause a backing of water from one pipe into another. When 2 or more drip pipes are taken from points near together, and where the pressure difference is likely to be slight, they may be connected with the same trap. It is usually best to seal them by means of a check which carries a water column above it, as shown in Fig. 26.

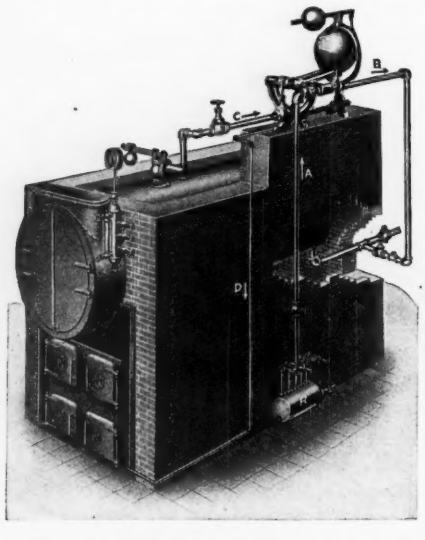


FIG. 31. RETURN TRAP PIPING CONNECTIONS

When drips coming from different sections of piping which are likely to be shut off are connected to the same trap, both check and gate valves should be placed in the connections. A method of grouping the drips so as to employ a single trap is shown in Fig. 27, and is applicable to cases where the piping arrangement is fairly compact.

In this system, the drips, with one exception, are brought to a receiving tank below the water line, each being provided with a gate and a check valve. The separate drip, one which is likely to be in use at all times as from the main header, is connected above the water line to serve as a balance or equalizing pipe. When the water in the tank rises to a certain point it overflows into the pump receiver or trap to be taken to the hot well.

### Outlet Traps

Traps are employed for draining water without allowing steam to escape at the same time. There are many forms, most of them, however, coming under the heads of float, bucket and expansion traps.

Figure 28 shows a simple form of float trap in which

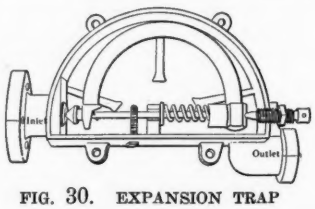



FIG. 30. EXPANSION TRAP

the rising water level causes the float to rise and open the discharge valve, A, which is placed near the bottom of the trap. As the water flows out, the float falls, and the valve closes before being uncovered, so that no steam escapes.

A bucket trap is shown in Fig. 29. In this case, the entering water fills the space around the bucket and floats it, thus closing the valve, A. After the space becomes filled, the water overflows into the bucket, causing it to sink. As the conical plug is attached to the bucket, the valve is opened, and water flows through openings in the surrounding sleeve, as indicated by the arrows, and is forced upward through the tube by the

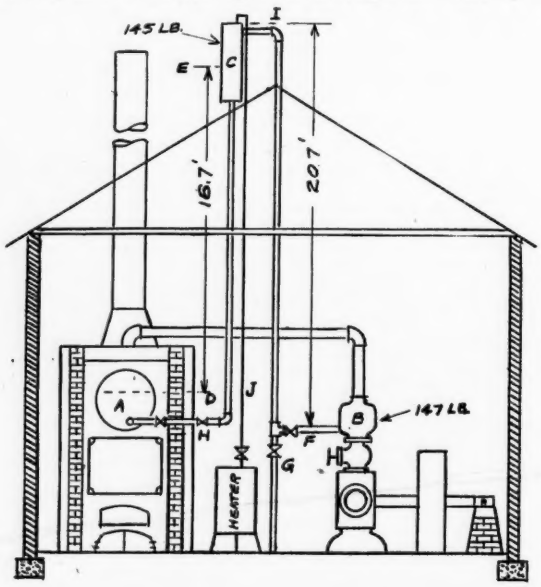



FIG. 32. HOLLY GRAVITY RETURN SYSTEM

steam pressure acting upon its surface. As soon as the bucket is partly emptied, it again rises and closes the valve before steam can escape.

Expansion traps are operated by the expansion and contraction of tubes or rods made of iron or brass; the difference between the expansion of these 2 metals under the same conditions of temperature being utilized in opening and closing the valve of the trap.

All traps should be provided with a bypass and cut-out valves, and where several traps discharge into a common main, it is well to place a check valve in each discharge pipe.

### Return Traps

The traps described above can only discharge their contents against a lower pressure. Where condensation is required to be discharged at boiler pressure, a device known as a return trap is used. It is simple in construction, and operates by the principle of equalizing the pressure in the trap and boiler.

Shown in Fig. 31 is the piping arrangement for a typical return trap. Condensation collects in the receiver, R, under pressure, and is lifted into the return trap through pipe A by the pressure. The trap is placed 3 ft. or more above the boiler water level. When filled, the receiving bowl tilts and opens the steam valve, admitting steam under boiler pressure through pipe C, which should connect directly to the boiler. Pressures on the trap and boiler are thus equalized, and since the trap

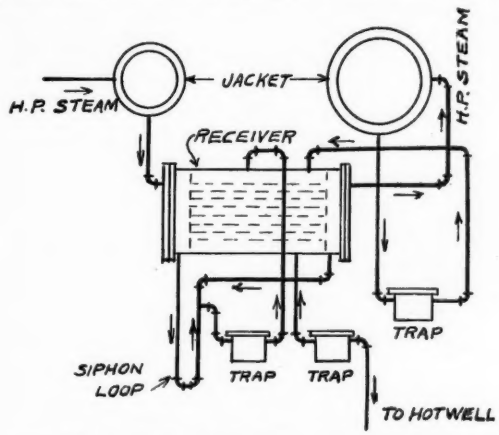



FIG. 33. DRAIN FOR CYLINDER AND RECEIVER

is above the boiler water line, the water will pass by the force of gravity from the trap to the boiler through pipe B. When empty, the bowl tilts back to the filling position and is ready for the next charge of water.

Horizontal check valves are placed in pipes A and B at the trap connection. An extra check valve and a stop valve are inserted below the water line in the outlet pipe, B. Vent pipe D can be left wide open in cases where the water supply is under low pressure or nearly cold; if under high pressure and the water has a high temperature, the vent can be partly closed.

### Holly Gravity Return System

There are drip systems in practical operation which return the water of condensation directly to the boiler. These systems, however, require special provisions; for instance, the Holly gravity return system, shown in Fig. 32, which operates as follows: The drip pipes from various points are led to a receiver, which is placed at a point below the lowest drainage outlet, usually about the central point of the plant. A riser pipe from the receiver reaches to the discharge chamber, which is 30 ft. or more above the boiler water level, and a return pipe connects the discharge chamber to the boiler at some point below the water level. Water of condensation is carried by the movement of steam to the discharge chamber by entrainment, and care is taken that the altitude of the discharge chamber is great enough to give sufficient head in the return line to restore the pressure loss under all conditions, and to make the return to the boiler.

This system is kept free from air, and the riser action is accelerated by the venting of a small amount of vapor from the discharge chamber, this commonly being discharged into the feed-water heater.

### Draining Receivers

Draining the jacket and receiver of a compound engine may be accomplished with the system shown in Fig. 33. Steam and condensation from the jacket of the high-pressure cylinder passes into the coil of the receiver from which it goes to the jacket of the low-pressure cylinder. The condensate is trapped into the shell of the receiver; also that from the heating coil. The receiver itself is drained through a trap to the hot well. This arrangement returns the condensate from the various high-pressure drips to the boilers without the use of traps or pumps.

## Auxiliary Steam Piping

In laying out power plant machinery, there are always a number of auxiliaries that take steam at boiler pressure, but their locations are secondary to the main units; the piping to these is, therefore, more or less complicated, making necessary the use of crossovers, off-sets, bypasses, reducing fittings, etc., in order to accomplish the desired result. It is usually found advisable to install an auxiliary main connected to the boiler header at convenient points. The advantages of this are that the main header is not cut up by numerous outlets to auxiliaries which in many cases would not

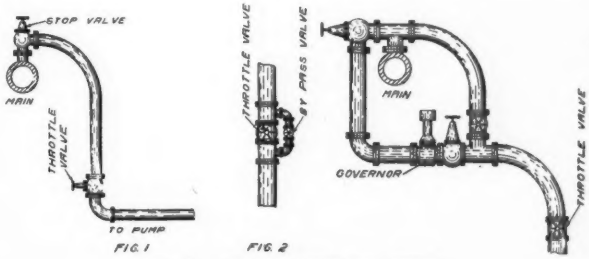



FIG. 1. STEAM LINE TO PUMP

FIG. 2. BYPASS VALVE USED FOR REGULATING

FIG. 3. PUMP PIPING INCLUDING GOVERNOR AND BYPASS

only be more expensive than the additional header, but interfere seriously with the flow of steam to the main units, reducing the efficiency of transmission. The auxiliary header also gives more liberty to the designer in locating small machinery. The same general principles govern the arrangement of the auxiliary piping as the main piping, the only difference being in regard to details of leads to various types of apparatus.

### To Pumps

Direct-acting steam pumps take steam nearly full stroke, so that there is no neecssity to provide receiver space in the branch, and if taken from the top of the main, which is properly drained, no drip connections to the branch will be necessary. When the pump is located

nearly under the main, the branch will need no additional support, but should have a stop valve at the main and a throttle valve at the pump. The stop valve is convenient when necessary to repair the throttle valve, which is subject to considerable wear, due to being kept partially open a great part of the time. A scheme resorted to occasionally to prevent excessive wear of the throttle valve is to provide a bypass with a valve one-fourth the size of the throttle. This valve is used to regulate the pump and naturally takes the wear, but

FIG. 4. COMMON PUMP CONNECTION
FIG. 5. SPECIAL PUMP CONNECTION USED TO SAVE SPACE

being smaller than the throttle will be opened wider, hence cutting of the seat will not be so great and when worn it is replaced at less expense.

In steam leads to pumps provided with governors, the governor should have a bypass pipe and valve and in the governor branch there should be a valve on each side of the governor to insure continuous running of the pump in case the governor needs repairs.

Many manufacturers of duplex pumps furnish a connection to the steam cylinders similar to that shown in Fig. 4, but frequently space can be saved by using a special connection such as shown in Fig. 5.

### To Compressors

Steam-driven air compressors are of 2 general types, direct acting and flywheel types. Steam piping for direct acting compressors is exactly similar to that for

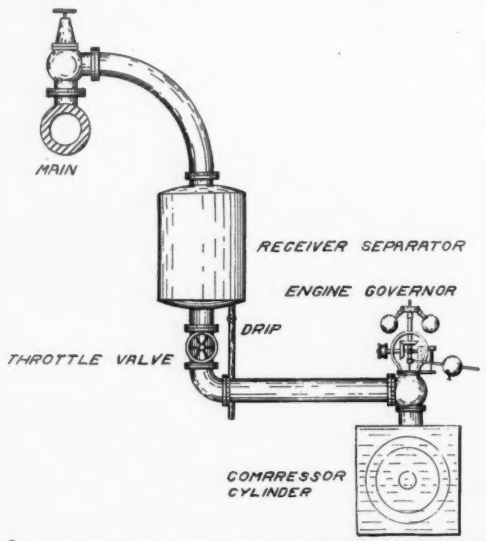



FIG. 6. STEAM PIPING TO FLYWHEEL TYPE AIR COMPRESSOR

pumps described above, but the flywheel type if compressor has a throttle governor usually of the flyball type run by belt from the compressor shaft with a pressure limiting device which stops and starts the engine, and as the steam works expansively it is advisable to install a receiver and provide drips for the line.

### Stoker Engines

During recent years, considerable study has been given to the operation of boiler furnaces. One of the results of this study is the development of an adequate system of speed control for stoker, fan and blower engines. Piping to these engines should include a receiver, as the steam is worked expansively and the pulsations in steam flow will cause the governor to chatter and wear rapidly.

Figure 7 is a diagram showing piping and a system of governing for blower, stoker and induced draft fan engines, the object of the control system being to maintain a rate of combustion which will give constant steam

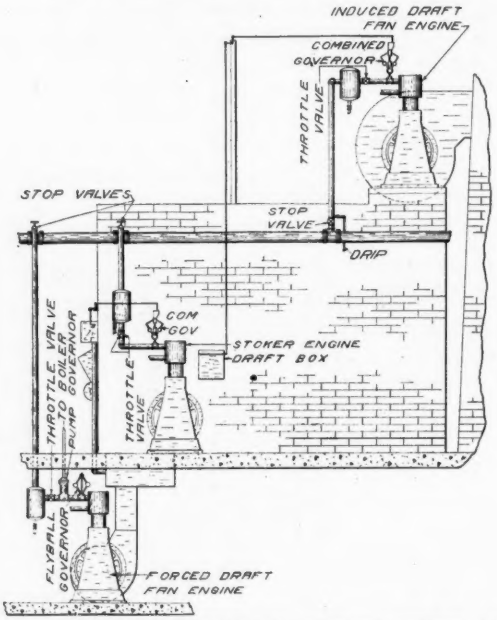



FIG. 7. STEAM CONNECTIONS TO ENGINES WHICH AUTOMATICALLY CONTROL COMBUSTION IN STOKER-FIRED BOILER FURNACE

pressure. The operation is as follows: The blower engine is operated at a speed which decreases as the steam pressure in the boiler increases above normal; a properly proportioned pump governor together with a flyball governor will serve here. The stoker engine speed is under the control of the air pressure in the wind box, increasing as the pressure increases, and vice versa, thus feeding coal in proportion to the air supplied. The speed of the induced draft fan engine is controlled by the air pressure in the furnace over the fire, this being maintained at or slightly below atmospheric.

Another practice is to have the speed of stoker engine, forced draft fan and induced draft fan regulated by a common control, as the draft should, of course, be varied with the rate of feed of the stoker, which, in turn, should be varied according to the steam demands of the boiler.

It is difficult to control all 3 engines by a single steam governor, both on account of the location of the engines at different points and because the action of the governor will not affect all 3 engines to the same degree. Suggestion is made by Morris that a rock shaft be

installed with levers controlling the steam valves of the various supply branches to the 3 engines, and that this rock shaft shall be operated by a device similar to a damper regulator, which, in turn, is controlled by the boiler pressure. Corliss type valves are suggested for use in the steam lines to the engines. If no induced draft is used, the damper control in the breeching should be connected, also, to this rock shaft, so that the damper, the stoker speed and the forced draft will all be varied proportionally. The Corliss control valves in the steam lines should be bypassed with a regular stop valve for emergency working.

### To Turbines

In plants having turbine main units it is common practice to employ turbine auxiliaries. The piping to these should be taken from the upper part of the main with a stop valve at the main and a throttle valve at the turbine. With the main properly drained there is no danger from condensation so no drips need be provided. In such plants the steam is usually highly superheated so that extra precautions must be made to allow for expansion, and valves and gaskets must be suitable for high temperatures. For the same amount of steam

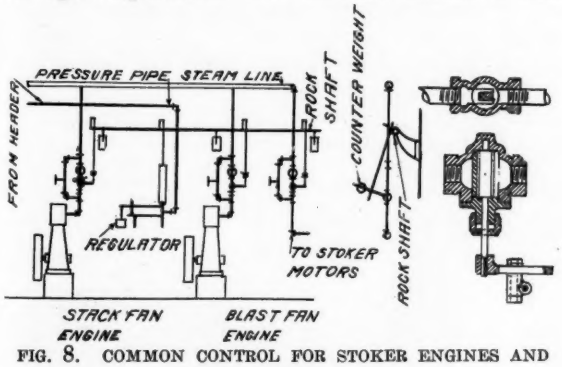



FIG. 8. COMMON CONTROL FOR STOKER ENGINES AND CORLISS STEAM VALVE

delivered to the unit the size of piping to the turbine is much smaller than is required for reciprocating engines, as the flow is continuous with the turbine while with the reciprocating engine, flow continues only during steam admission. For this reason, also, no receiver space is necessary in the pipe line.

### Automatic Control

In power plants, the operation of the various equipment is so interlocked that a change in demand for steam, calls for changes in the speed of all auxiliary machinery. In small plants where the time of the operator is not too fully occupied, much of this regulation is done by hand; but in large plants, the tendency is toward automatic control wherever possible.

It is not within the scope of this article to describe the various methods of automatic control of steam-driven auxiliaries, but merely to point out typical methods and wherein the method of piping must be changed to accommodate the automatic governors.

Steam pumps are used either to maintain a water pressure within certain limits in a tank or piping system, or to maintain a water level within definite limits. In any case, control of the pump speed is effected by varying the supply of steam to the pump. When this is done by hand, the speed varies with the amount the throttle valve is opened and a single steam pipe with valve at the main and at the pump is all that is required; with automatic control, a special governor valve is used and, due to its necessary delicacy, it may get out of order at a most important moment, so that a bypass should be provided. A valve on each side of the governor and one in the bypass makes it possible to repair the governor without shutting down the pump.

Reciprocating flywheel engines are used largely for the operation of stokers, blowers, draft fans, etc., their maximum speed being limited by some form of centrifugal governor. Automatic regulation consists in reducing the speed from that maintained by the engine

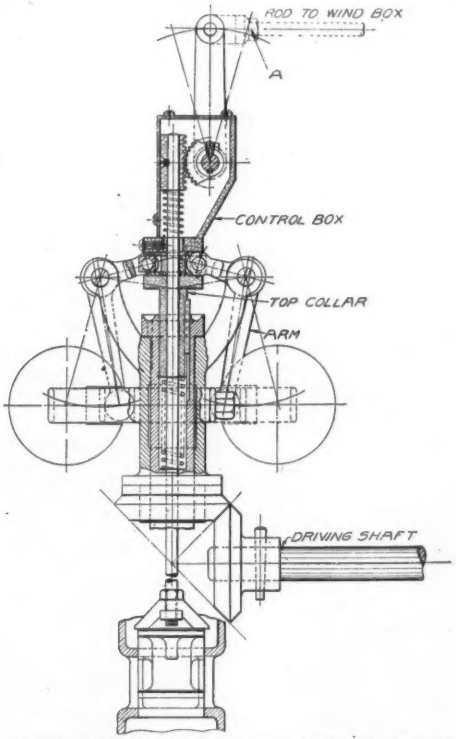



FIG. 9. CROSS SECTION OF WATERS GOVERNOR FOR STOKER ENGINES WHEN FORCED DRAFT IS EMPLOYED

governor to that most desirable for carrying on the operation of the plant. In most cases it is desirable to have a special governor of the throttling type combining both centrifugal and special governing features in one valve. Such a governor is shown in Fig. 9, and should not be bypassed, but where the special automatic control governor is separate from the centrifugal governor, as in the steam lead, it should be bypassed as in the case of the pump, and if the distance from the governor to the engine is short, a receiver should be installed, otherwise the pulsations in the flow of steam to the engine will cause excessive wear of the governor.

Turbine governors are exceedingly delicate, and it is not practical to attempt varying the speed of a turbine-driven auxiliary with a combined governor. The better plan for pumps or blowers is to provide a special valve, located in the discharge line, for cutting down the delivery according to demands. Turbine-driven exciters have their output controlled from the electrical side, the speed being maintained constant.

# Reducing Systems

## Types of Valves Employed

WHEN steam, air, illuminating gas, etc., are utilized at pressures lower than that at which generated, some form of automatically-operated throttle valve generally known as a pressure reducing or as sometimes termed, pressure regulating valve, is employed.

In the simple weighted type shown in Figs. 1 and 2, the low-pressure steam is caused to act upon a flexible diaphragm in opposition to an adjustably weighted lever. With a given supply-line pressure and weight setting and a constant flow of steam, a fixed low pressure is maintained. As the demand for low-pressure steam is increased, however, the pressure against the diaphragm is partially reduced, causing the balanced valve to open and admit more steam until the required pressure has again been established; on the other hand, should the flow of steam be restricted and the low pressure increase, the diaphragm will move in the opposite direction and the balanced valve caused partly to shut off the supply of steam to the low-pressure side.

Representative single-diaphragm spring-operated reducing valves are shown in Figs. 3 and 4. As soon as valve 11, Fig. 3, is open, steam passes through port N, and under piston 17, raising it and opening main valve 16 against the supply pressure; when the service pressure has reached its required value, determined by tension

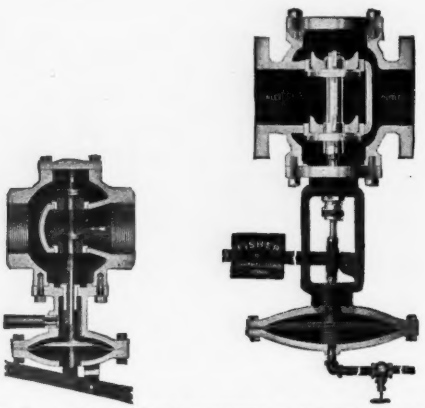


FIG. 1. CRANE LOW-PRESSURE REDUCING VALVE
FIG. 2. CROSS SECTION FISHER REDUCING VALVE

of adjustable spring 31, the diaphragm is forced upward, and valve 11 closed, releasing the pressure under piston 17. Valve 16 is now forced to its seat by the supply pressure, shutting off the service steam and pushing piston 17 down to the bottom of its stroke. Piston 17 being a comparatively loose fit, the steam under it readily escapes into the system.

In the pressure regulator illustrated in Fig. 4, 2 springs mounted externally act against the pressure of the steam through the medium of 2 toggle joints, the diaphragm, its connecting levers, and the valve stem. When steam first enters, it passes through the valve and into the service pipe, a small portion of it, however, entering the diaphragm chamber, raising the diaphragm and closing the main valve. With a reduction of delivery pressure the springs overcome the pressure acting on the under side of the diaphragm, causing the valve to open and admit sufficient steam to maintain the desired delivery pressure. This is controlled by adjusting nuts on the spring bolts—turning to the right increases and to the left decreases the delivery pressure.

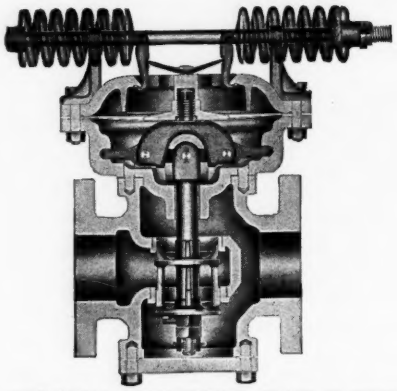


FIG. 4. SECTIONAL VIEW FOSTER CLASS W REGULATOR

Another spring-operated regulating valve, but fitted with 2 diaphragms, is illustrated in Fig. 5. Steam entering at A passes upward between the stem of main valve 13, and guide nut 15, and divides, a part entering chamber E and the remainder by way of ports C, going to chamber D; then through port F and pipe 23 to the small chamber above controlling valve 25.

The valve is placed in operation by turning hand-

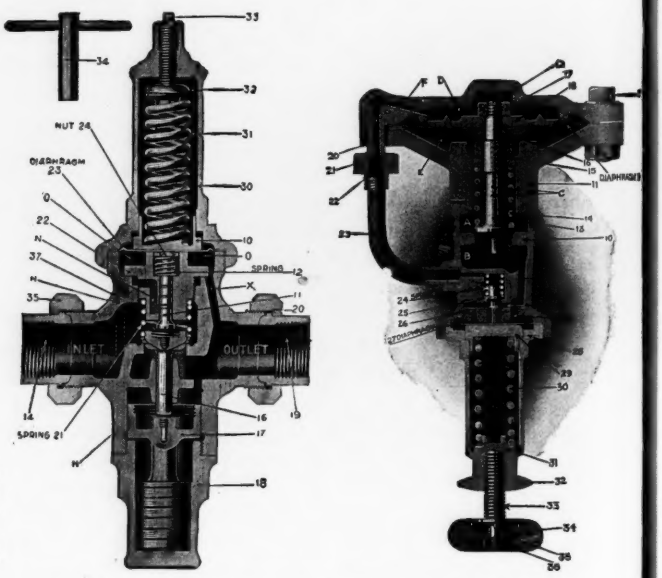



FIG. 3. SECTIONAL VIEW MASON STANDARD REDUCING VALVE
FIG. 5. SECTIONAL VIEW, TYPE F REGULATOR, THE OHIO BRASS CO.

wheel 34 to the right. This compresses regulating spring 30 and forces controlling diaphragm 27 upward, which in turn lifts controlling valve 25 from its seat, and as a result the pressure chamber D is reduced and main valve 13 raised from its seat, admitting steam through the main valve port to the service side B. The pressure

here acts on diaphragm 27, through ports H and J, and when this pressure exceeds that which the valve is set to deliver it forces diaphragm 27 downward and permits valve 25 to shut off the steam from chamber D. As a consequence the pressure is again built up in chamber D until equal to that in chamber E, when the pressure of the steam against the top of valve 13, supplemented by the action of spring 14, closes it and shuts off the steam to the service side. When the service pressure falls below that which the valve is set to deliver, spring 30 overcomes the service pressure and lifts diaphragm 27, together with valve 25, from its seat, again causing a pressure drop in chamber D and allowing the cycle to repeat.

Steam for the operation of the main diaphragm of the valve shown in Fig. 6, is taken from the high-pressure supply line, throttled by means of a graduated valve, and controlled by a resistance plug attached to the stem of an auxiliary diaphragm in communication with the low-pressure service at A.

at its lower end by the tube cap and reinforced by a number of telescoping rings which permit the tube to expand lengthwise only. With the valve partially or fully closed, the rubber tube is extended, the rings, due to their construction, assuming equal positions along its length; as the tube contracts, due to the opening of the valve, the rings telescope and assume the positions shown.

With a given setting of the adjusting screw, the low pressure acting against the upper side of the main valve will tend to disturb the equilibrium established between the pressure acting against the lower side of the valve and the tube cap until exactly counterbalanced by the tension of the springs. When this pressure exceeds the tension of the springs, the valve moves toward its seat, thus restricting the steam flow and reducing the low pressure; when this pressure is less than the tension of the spring, the valve moves from its seat and allows a greater flow of steam with a resulting increase in service pressure.

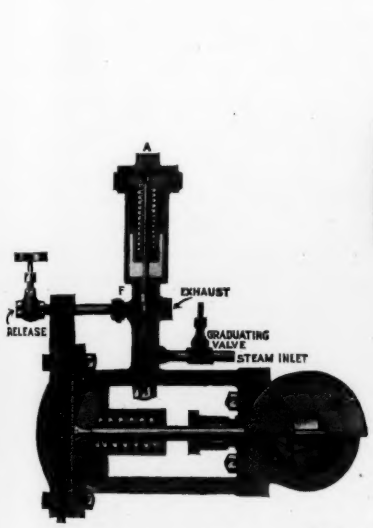
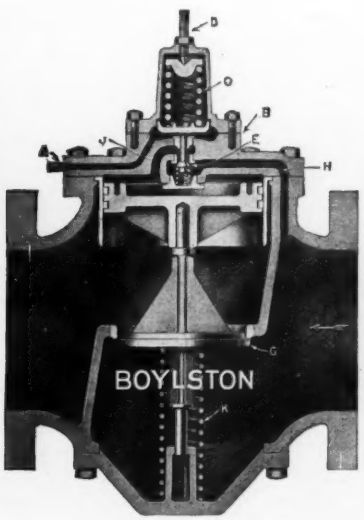


FIG. 6. SECTIONAL VIEW SQUIRES REDUCING VALVE
FIG. 7. SECTION ELLIOTT TYPE A REDUCING VALVE



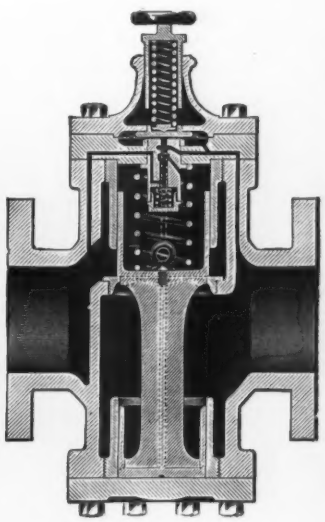



FIG. 8. BOYLSTON HIGH-PRESSURE PILOT REDUCING VALVE
FIG. 9. CURTIS IMPROVED PRESSURE REGULATOR FOR STEAM

With increased service pressure, the pilot valve is caused to close communication between the main diaphragm chamber and the exhaust, resulting in a building up of pressure within this chamber and the closing of the main valve. With decreased service pressure, the pressure within the main diaphragm chamber is released by way of the exhaust and the main valve is allowed to open.

Service pressure is controlled by adjusting sleeve at bottom of pilot-valve spring.

A combined reducing and relief valve embodying somewhat unique construction is shown in section, Fig. 7. Regulation of pressure reduction is obtained by balancing the pressure exerted on the upper side of the main valve against the tension of a pair of externally mounted springs, by means of an India rubber tube supported at its upper end by the distance piece and

In the valve shown in Fig. 8, the reduced pressure acting against the bottom of the diaphragm B, balanced by adjustable spring C, controls the operation of valve E. With the opening of this valve, due to low service pressure, high-pressure steam is admitted to the top of piston F which, being forced downward, opens valve G; with an excess of service pressure valve E is closed and the pressure removed from above piston F with the consequent closing of valve G by the high pressure and spring K. Steam above piston F exhausts freely around it and passes off into the system.

The sectional view in Fig. 9 shows a main valve operated by a loose-fitting piston; a secondary valve in the top of the chamber over the piston; a metallic diaphragm operating the secondary valve, and a side passage connecting the chamber under the diaphragm with the outlet. When the spring over the diaphragm is compressed the diaphragm gives way, and thus opens

the secondary valve, allowing the steam to escape from the upper side of the main piston valve into the low service, and at the same time opening a port to the under side of the piston, admitting full boiler pressure, which lifts the main piston valve open to its full capacity.

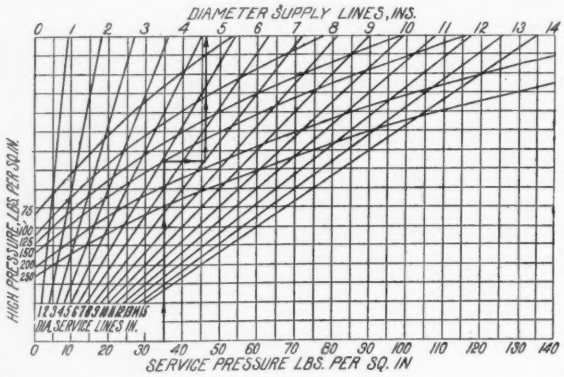

DIAMETER SUPPLY LINES, INS.
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
HIGH PRESSURE LBS. PER SQ. IN.
75
100
125
150
200
250
1 2 3 4 5 6 7 8 9 10 12 HARDING DIA. SERVICE LINES IN.
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140
SERVICE PRESSURE LBS. PER SQ. IN

FIG. 10. SIZES OF REDUCING VALVES AND SUPPLY LINES TO BE USED WITH VARIOUS SERVICE PRESSURES AND SIZES OF SERVICE LINES

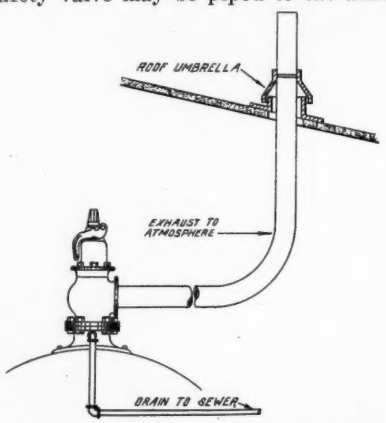
The main valve remains open until the back pressure, communicated from the outlet through the side passage, is sufficient to raise the diaphragm and thus close the secondary valve, shutting off high pressure from the bottom of the piston; the high-pressure steam or water then passes by the loose-fitting piston into the space above it forcing it to its seat, and in this manner uniformly maintaining the pressure at which it is set.

# Safety Valves

## Proper Method of Installation

ALL safety valves should be directly connected to the highest possible point on the boiler and independent of any other steam connection except the Y base forming the support for twin valves. The area of the opening in the boiler must be equal at least to the aggregate area of all the safety valves with which it connects, screwed connections being permissible on low-pressure heating boilers only. No shutoff of any description should be employed between the safety valve and the boiler nor on the discharge pipe if such is used.

If the escape of steam becomes a nuisance, the outlet of the safety valve may be piped to the atmosphere, in




PROPER METHOD OF ATTACHING SAFETY VALVE TO BOILER SHELL AND PIPING LIVE STEAM DISCHARGE AND DRAIN

TABLE I. DISCHARGE CAPACITIES FOR DIRECT SPRING LOADED POP SAFETY VALVES

| Gage Pressure, Lb. | | 1 In. | 1½ In. | 2 In. | 2½ In. | 3 In. | 3½ In. | 4 In. | 4½ In. |
|---|---|---|---|---|---|---|---|---|---|
| 15 | Lift, in. | 0.057 | 0.070 | 0.083 | 0.096 | 0.109 | 0.122 | 0.135 | 0.147 |
| | CH 45 deg. seat | 272,300 | 501,600 | 793,000 | 1,147,000 | 1,562,000 | 2,040,000 | 2,580,000 | 3,158,000 |
| | CH flat seat | 385,100 | 709,400 | 1,122,000 | 1,622,000 | 2,209,000 | 2,885,000 | 3,648,000 | 4,466,000 |
| 25 | Lift, in. | 0.056 | 0.069 | 0.082 | 0.095 | 0.107 | 0.120 | 0.132 | 0.144 |
| | CH 45 deg. seat | 357,100 | 657,800 | 1,047,000 | 1,513,000 | 2,050,000 | 2,682,000 | 3,384,000 | 4,138,000 |
| | CH flat seat | 505,000 | 930,200 | 1,481,000 | 2,140,000 | 2,899,000 | 3,793,000 | 4,786,000 | 5,852,000 |
| 50 | Lift, in. | 0.053 | 0.065 | 0.078 | 0.090 | 0.102 | 0.114 | 0.127 | 0.138 |
| | CH 45 deg. seat | 551,500 | 1,020,000 | 1,624,000 | 2,342,000 | 3,185,000 | 4,153,000 | 5,287,000 | 6,463,000 |
| | CH flat seat | 780,000 | 1,442,000 | 2,296,000 | 3,312,000 | 4,504,000 | 5,873,000 | 7,477,000 | 9,140,000 |
| 75 | Lift, in. | 0.050 | 0.062 | 0.074 | 0.086 | 0.097 | 0.109 | 0.121 | 0.132 |
| | CH 45 deg. seat | 721,200 | 1,342,000 | 2,135,000 | 3,102,000 | 4,198,000 | 5,498,000 | 6,983,000 | 8,570,000 |
| | CH flat seat | 1,020,000 | 1,898,000 | 3,020,000 | 4,387,000 | 5,938,000 | 7,775,000 | 9,876,000 | 12,120,000 |
| 100 | Lift, in. | 0.047 | 0.058 | 0.069 | 0.081 | 0.093 | 0.104 | 0.115 | 0.126 |
| | CH 45 deg. seat | 866,900 | 1,605,000 | 2,546,000 | 3,727,000 | 5,093,000 | 6,698,000 | 8,487,000 | 10,462,000 |
| | CH flat seat | 1,226,000 | 2,270,000 | 3,601,000 | 5,271,000 | 7,202,000 | 9,473,000 | 12,003,000 | 14,796,000 |
| 125 | Lift, in. | 0.044 | 0.055 | 0.066 | 0.077 | 0.087 | 0.098 | 0.109 | 0.120 |
| | CH 45 deg. seat | 988,500 | 1,843,000 | 2,966,000 | 4,315,000 | 5,865,000 | 7,707,000 | 9,798,000 | 12,135,000 |
| | CH flat seat | 1,398,000 | 2,606,000 | 4,195,000 | 6,102,000 | 8,295,000 | 10,900,000 | 13,856,000 | 17,161,000 |
| 150 | Lift, in. | 0.041 | 0.051 | 0.062 | 0.072 | 0.082 | 0.093 | 0.104 | 0.114 |
| | CH 45 deg. seat | 1,086,000 | 2,013,000 | 3,285,000 | 4,769,000 | 6,517,000 | 8,610,000 | 11,021,000 | 13,591,000 |
| | CH flat seat | 1,536,000 | 2,847,000 | 4,646,000 | 6,744,000 | 9,217,000 | 12,177,000 | 15,586,000 | 19,221,000 |
| 175 | Lift, in. | 0.038 | 0.048 | 0.058 | 0.068 | 0.078 | 0.088 | 0.098 | 0.107 |
| | CH 45 deg. seat | 1,159,000 | 2,197,000 | 3,540,000 | 5,187,000 | 7,140,000 | 9,399,000 | 11,961,000 | 14,677,000 |
| | CH flat seat | 1,640,000 | 3,107,000 | 5,006,000 | 7,336,000 | 10,098,000 | 13,292,000 | 16,916,000 | 20,757,000 |
| 200 | Lift, in. | 0.035 | 0.044 | 0.054 | 0.063 | 0.072 | 0.082 | 0.092 | 0.101 |
| | CH 45 deg. seat | 1,208,000 | 2,280,000 | 3,730,000 | 5,422,000 | 7,460,000 | 9,912,000 | 12,710,000 | 15,679,000 |
| | CH flat seat | 1,709,000 | 3,224,000 | 5,275,000 | 7,668,000 | 10,550,000 | 14,017,000 | 17,974,000 | 22,174,000 |
| 225 | Lift, in. | 0.031 | 0.040 | 0.049 | 0.059 | 0.068 | 0.077 | 0.086 | 0.095 |
| | CH 45 deg. seat | 1,095,000 | 2,314,000 | 3,779,000 | 5,668,000 | 7,866,000 | 10,372,000 | 13,264,000 | 16,351,000 |
| | CH flat seat | 1,690,000 | 3,272,000 | 5,344,000 | 8,016,000 | 11,124,000 | 14,688,000 | 18,758,000 | 23,124,000 |
| 250 | Lift, in. | 0.028 | 0.037 | 0.046 | 0.054 | 0.063 | 0.072 | 0.080 | 0.088 |
| | CH 45 deg. seat | 1,192,000 | 2,342,000 | 3,917,000 | 5,748,000 | 8,048,000 | 10,730,000 | 13,625,000 | 16,861,000 |
| | CH flat seat | 1,686,000 | 3,312,000 | 5,540,000 | 8,129,000 | 11,381,000 | 15,174,000 | 19,269,000 | 23,845,000 |
| 275 | Lift, in. | 0.025 | 0.033 | 0.042 | 0.050 | 0.058 | 0.066 | 0.074 | 0.082 |
| | CH 45 deg. seat | 1,165,000 | 2,283,000 | 3,915,000 | 5,825,000 | 8,108,000 | 10,765,000 | 13,794,000 | 17,195,000 |
| | CH flat seat | 1,648,000 | 3,229,000 | 5,536,000 | 8,238,000 | 11,467,000 | 15,224,000 | 19,507,000 | 24,318,000 |
| 300 | Lift, in. | 0.022 | 0.030 | 0.037 | 0.045 | 0.053 | 0.061 | 0.069 | 0.078 |
| | CH 45 deg. seat | 1,114,000 | 2,278,000 | 3,746,000 | 5,670,000 | 8,049,000 | 10,783,000 | 13,972,000 | 17,313,000 |
| | CH flat seat | 1,575,000 | 3,222,000 | 5,298,000 | 8,018,000 | 11,383,000 | 15,249,000 | 19,759,000 | 24,484,000 |

which case the pipe so used must be of a diameter equal to, or greater than, the diameter of the valve disc, and must be properly drained to avoid the collection of water. If the discharge pipe is of considerable weight, it should be supported properly to relieve the valve body of any strain, and when placed in a vertical position, a large radius bend with bleeder attached to the lowest point to remove all condensation should be used instead of an ell.

The safety valve drain should be free to the atmosphere at all times to avoid damage due to condensation remaining in the valve and causing water hammer when the steam is escaping.

The Boiler Code Committee of the A. S. M. E. recommends basing the size of pop safety valves upon the steaming capacity of the boiler and has prepared the accompanying table of Discharge Capacities for Direct Spring Loaded Pop Safety Valves in which the discharge capacity of each valve size at the given pressure is calculated upon the values of lifts unanimously approved by safety valve manufacturers. C is the total weight in pounds of fuel burned per hour at time of maximum forcing, and H is the heat of combustion in British thermal units per pound of the fuel used. In preparing this table, a boiler efficiency of 75 per cent and a valve discharge efficiency of 96 per cent were assumed.

## Steam for Special Services

FOR such stokers as are operated by a steam cylinder directly connected to the stoker plunger, the steam supply line should be run above the stoker cylinder and the exhaust line below, so that any condensation in the steam line will be worked through the cylinder and out of the exhaust.

Where steam jets are used for smoke-consumer operation or for induced draft, the steam supply may be taken from the same line that supplies the stoker engines, or if no stokers are used, from a special boiler room supply line. These devices should be controlled by hand-operated stop valves, and should be provided with drips so that any condensation may be gotten rid of before starting the steam jets to working. Generally, the condensation after starting up will be so small that there is no need for a continuous drain.

### Soot Blowers

ANOTHER DEVICE which will be supplied from the boiler room line is the soot blower, whether hand operated or permanently installed. For a hand operated blower, the outlet to which the steam hose is attached should have a stop valve, then a strong support, to resist the strain from moving the blower about, and a quick opening valve should be provided at the inlet to the hose, with an operating cord which can be carried with the blower, in this way controlling the admission of steam to the hose rather than using a control valve at the blower end of the hose.

For the fixed type of tube blower, a stop valve should be provided near the inlet to the nozzles, with a drip ahead of it so that all condensation may be removed from the line before operating the jets. There should, also, be a stop valve as near as possible to the main, to keep condensation out of the branch to the blower. Any water blown through the jets on to the tubes and thus coming in contact with the soot is bad, as it cools down the tubes and also, combining with the soot, sticks the soot to the tubes and forms acids which will start corrosion.

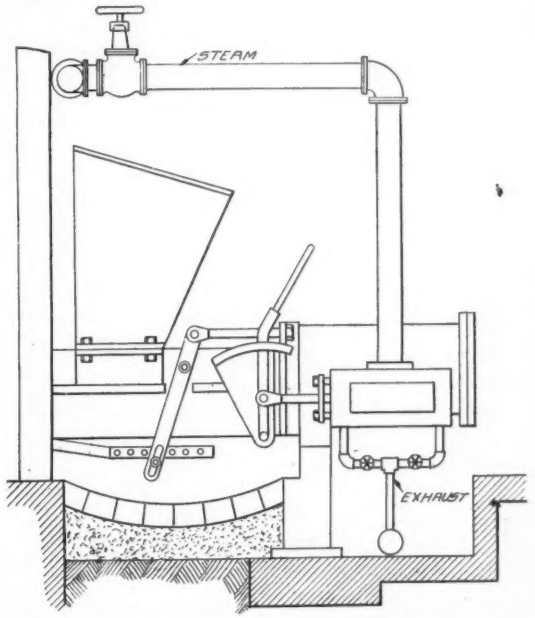



FIG. 1. ARRANGEMENT OF STEAM LINE FOR STOKER ENGINES

For supplying steam to whistles, the branch should be taken from the top of the main and the valve placed near this connection. The whistle being above the roof will have a long vertical supply pipe, and condensation will tend to collect above the steam supply valve. This should be taken off by a drain valve placed close above the steam valve, and preferably of automatic type. A horizontal ball check valve may be used set vertical so as to open upward, so that when there is no pressure in the whistle line, the ball will roll back from its seat and allow the condensation to drain out, but when steam pressure is admitted, this will throw the ball to its seat and prevent the escape of steam.

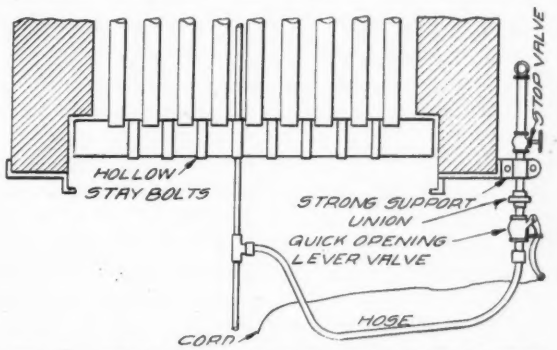



FIG. 2. STEAM CONNECTION FOR HAND SOOT BLOWER

### Oil Filter

FOR THE oiling system, steam should be supplied for blowing out of oil return pipes to remove gummed oil and sediment, and also for heating the oil in the filters.

For blowing out the lines, piping should be so arranged that steam alone, or a steam and hot water jet combined, can be sent through the pipes. For small plants, this can be obtained by a ½-in. steam line with branch to the coil through the oil filter, and with a separate branch having connected to it a ¾-in. siphon tee for drawing in water, and a hose connection so that the hose may be used to blow out any pipe in the oiling system. For larger plants it will be desirable to install a permanent connection to the oil return main, bringing the pipes from all engines and other machines into this main, which discharges to the oil filter. There should be a permanent blowout nozzle at one end of this drip main, with steam and water connections, and a hose connection outlet; also an outlet from the other end of the main to atmosphere, so that the sediment may be blown and washed out and discharged on to the ground.

### Wash Room Steam

For wash rooms, live steam outlets with hand control should be avoided on account of the danger of scalding. The wash water should be heated by closed coils in a heating tank, with thermostat control on the steam supply line, the condensation from this heater coil discharging into the water, or if preferred, it may be returned to the hot well. When exhaust steam is used, the condensation from the heating coils should be thrown away because of the oil contained, never put into the wash or feed water.

For small plants, it may be desirable to use a water coil for heating, placed in the exhaust pipe, or a water tube, exhaust steam heater may be used. In such case, the water should be sent in at the bottom of the coil and taken off at the top in order to have the water drawn from the hottest point. For the hot water tank, a trombone steam coil may be used if of the horizontal type, or a spiral coil if of the vertical type, brass pipe being used for the coils, as this will give a much better transmission of heat than iron coils. The tank should be of a size to care for the greatest demands for wash water at noon and night, allowing one gallon capacity for each person to use the wash room. Connections are shown under House Service Water Piping.

If water at 40 deg. temperature is to be heated to 190 deg., at the rate of 100 gal. per hour, with steam at 5 lb. pressure, it will require about 5.5 sq. ft. of heating surface in the heating coil.

### Steam Jackets and Receivers

For steam jackets of engine cylinders, and intermediate receivers for compound engines, live steam should be supplied at full boiler pressure, and this should be taken from the pipe in such a way as to insure as dry steam as possible. Water passed through cylinder jackets or the heating coils of a receiver serves no useful purpose, and simply clogs up the steam. As the condensation from jackets and receiver coils will be at full boiler pressure and temperature, it is desirable to collect this in a special tank and return it direct to the boiler; but if the plant be small, it may be better economy to waste a certain amount of heat and send this water to an open feed heater or to the hot well. Condensation from the steam separator on the supply line to the engine may well be piped to the same main as the condensation from jackets and receiver coils.

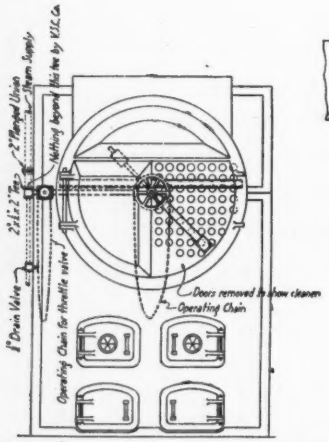



FIG. 3. STEAM SUPPLY FOR FIXED TUBE BLOWER

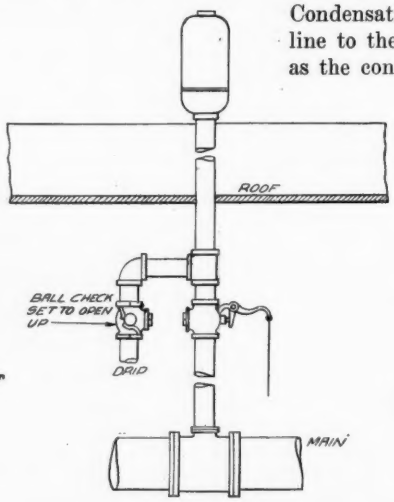



FIG. 4. STEAM CONNECTION AND AUTOMATIC DRIP FOR WHISTLE PIPE

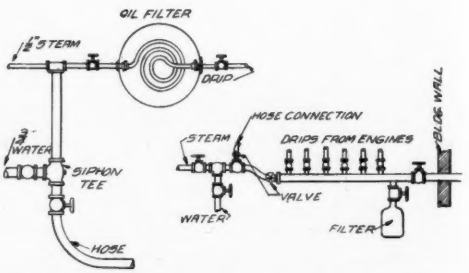



FIG. 5. ARRANGEMENTS FOR STEAM SUPPLY TO OIL RETURN SYSTEM

In piping up a compound or triple expansion engine, provision must be made for operating the high-pressure cylinder with the low-pressure cylinder non-operative, or for supplying live steam at reduced pressure to operate the low-pressure cylinder with the high-pressure non-operative, in case there are 3 or less units in the plant. For more than 3 units, it does not pay to install this complication, as it will be better to leave one unit entirely out of commission and operate the plant with those which are able to run until repairs can be made.

A branch should be taken from the exhaust connection between the high-pressure cylinder and the receiver, to exhaust either into the condenser or to atmosphere, with, of course, the proper stop valves to shut off this branch during normal operation. The steam supply to the receiver for operating the low-pressure cylinder alone should be taken through a reducing valve which will

cut the pressure down to 25 lb. in the receiver, and should have stop valves on both sides of the reducing valve so that this may be isolated for overhauling. There should be, also, a relief valve between the receiver and the low-pressure cylinder, set to blow at 25 lb. pressure, to avoid the possibility of high-pressure steam entering the low-pressure cylinder. Long bends should be used in all connections between the engine cylinders and the receiver, in order to permit of expansion in the different pipe connections. Straight-through connections are sure to result in strains that will tend to open up the joints.

In engines which have a device for working steam through the high-pressure cylinder when starting up, the receiver and low-pressure cylinder may be warmed in this way; but if there is no such method, then provision should be made for bypassing live steam at high pressure into the receiver and low-pressure cylinder, in order to warm up the engine before starting.

Each jacket should be supplied by an independent branch from the steam line rather than by sending condensation from the high-pressure cylinder through the jacket of the low-pressure. While the low-pressure cylinder may take up some heat from the condensation received from the high-pressure jacket, the advantage is slight, and the ability to operate either jacket independently of the other is of great advantage.

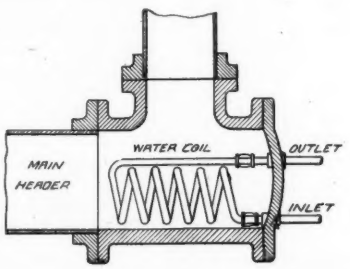



FIG. 6. WATER COIL HEATER IN EXHAUST PIPE

Drips must be installed from the intermediate receivers, to take care of any steam which condenses there, and it is wise to waste this condensation through a trap to the sewer, as it will contain cylinder oil and is of small account. A typical installation is illustrated in the drawing herewith, Fig. 7.

Steam for operating tube cleaners, where steam-driven cleaners are in use, may be taken from the line which supplies the soot blowers, either from the hose connection in the case of a hand blower system, or from a supply outlet in the case of permanent blowers. Such an outlet is essential in any case, as steam will be wanted frequently in the boiler room for various uses, and sufficient outlets should be provided so that steam may be available at any point in the boiler room without the use of long steam hose connections. Preferably one outlet should be provided for each battery of boilers, or an outlet between each 2 batteries.

### Roof Tank Coil

Where roof tanks are installed, either for general water supply or for fire use, it is necessary, in winter, that the water should be heated so that it will not freeze. For this purpose, a 1-in. steam line should be run to take steam to the tank, low-pressure steam being suitable if available; if not, high-pressure steam may be used. Exhaust steam will seldom have sufficient pressure to be serviceable for this purpose.

The steam pipe should be carried up beside the discharge pipe from the roof tank, as indicated in the drawing under the section relating to water supply for roof tanks, and where the pipe is carried outdoors, both water pipe and steam pipe should be enclosed in frost boxes. The steam pipe is carried through the bottom of the tank, and a desirable arrangement is to carry the heating coil, of brass pipe, out toward the circumference of the tank in a square, as shown in the illustration, turning up the discharge end, carrying it above the water level in the tank, when turning over and coming down to a point at least 3 ft. below the water level. The end should then be turned horizontal with an ell, so that the condensation and discharged steam may be blown into the water toward the coldest side of the tank, thus tending to assist the circulation of hot water toward that point. A vent should be provided in the upper horizontal run of the discharge end, to prevent siphoning of water back into the steam coil. The amount of piping to be installed is as shown in the table for roof tanks, this amount of surface providing sufficient heat to raise the temperature of the contained water 10 deg. in 30 min., to take care of emergency conditions during a cold spell. Ordinarily it is necessary to keep the temperature of the water only some 10 or 15 deg. above freezing point, to prevent formation of anchor ice.

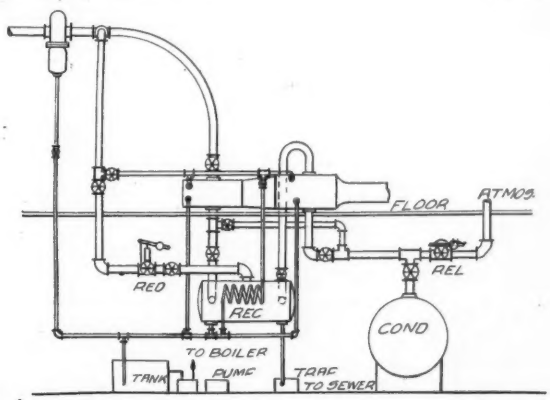



FIG. 7. ARRANGEMENT OF PIPING FOR STEAM JACKETS AND RECEIVER

To control the steam admission to this pipe, a valve should be located at an accessible point in the boiler room, and provision should be made for a drip outlet which is left open at all times when the steam coil is not in use, to drain off condensation or any leakage which may get into the steam pipe from the tank.

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Iowa Railway & Light Co. is successfully using underwater storage for Iowa coal, which readily ignites from spontaneous combustion when piled in the open. The reserve is stored in a flooded pit, from which it is reclaimed when needed by an electric locomotive crane.

# Exhaust Lines

## Connections to Atmosphere, Heating Systems, Feed-Water Heaters and Condensers

ATMOSPHERIC exhaust lines should be of the same size as the exhaust main, or if supplied by more than one such main, equal to their combined areas, and if used in connection with noncondensing units should be provided with a sealed drain and fitted with an exhaust head with drain and a short seal. Where engines and turbines are operated condensing, no exhaust head is necessary.

To care for expansion and contraction and prevent leakage, exhaust and drain pipes passing through roofs should be fitted with some form of sleeve and umbrella and where the vertical run is more than 25 ft., the depth of the drop flange of this umbrella should correspond to the amount of travel caused by expansion. This for an exhaust line subject to temperature variations of from 32 to 212 deg. F. would be about 1¼ in. for every 100 ft.

Exhaust heads are generally made of sheet metal or cast iron, so constructed internally as to cause a change of direction in the flow of the steam, while the entrained water which tends to follow a straight path continues and is caught in some suitable form of receptacle or trough. Due to the oil which this water generally contains, it is trapped directly to the sewers.

In selecting exhaust heads, care should be taken to avoid any having greatly reduced sections and twisting passages tending to produce excessive back pressures and thereby interfere with the proper operation of engines and pumps.

### Back-Pressure Valves

Back-pressure and atmospheric-relief valves, which serve primarily as safety valves on exhaust-steam-heating and engine-and-turbine atmospheric-exhaust lines, are of 3 general types; single, double or balanced, and multiple for horizontal or vertical mounting. The single-seated valve is best for diameters up to 6 in.; for larger sizes balanced and multiple valves are more suitable. When used in connection with condensing engines and turbines, these valves are frequently water sealed, a ½-in. connection supplying all the necessary water for such service.

Loading is accomplished by means of springs or weights, which like the cushioning cylinders and pistons, if such are used, may be mounted externally or internally as shown in the accompanying illustrations of commercial types. Some of these valves close automatically while others require manual aid.

Atmospheric exhaust lines used in connection with engines and turbines should always be installed vertical and the relief valve used in connection therewith may be 1 or 2 in. less in diameter than this line, a 14-in. valve being suitable for a 16-in. line, a 12-in. valve for a 14-in. line, etc.

### Mains and Returns

As shown in the scheme of connections of typical exhaust heating installations, Fig. 1, exhaust from the prime movers may be piped direct to the feed-water heater, the system taking all surplus steam except during the warm months when this, if not required for other purposes, is diverted to the atmosphere through a back-pressure relief valve. This should be placed above the highest distributing main and in order to allow repairs without interfering with the operation of the system, a bypass and necessary cutout valves are frequently provided.

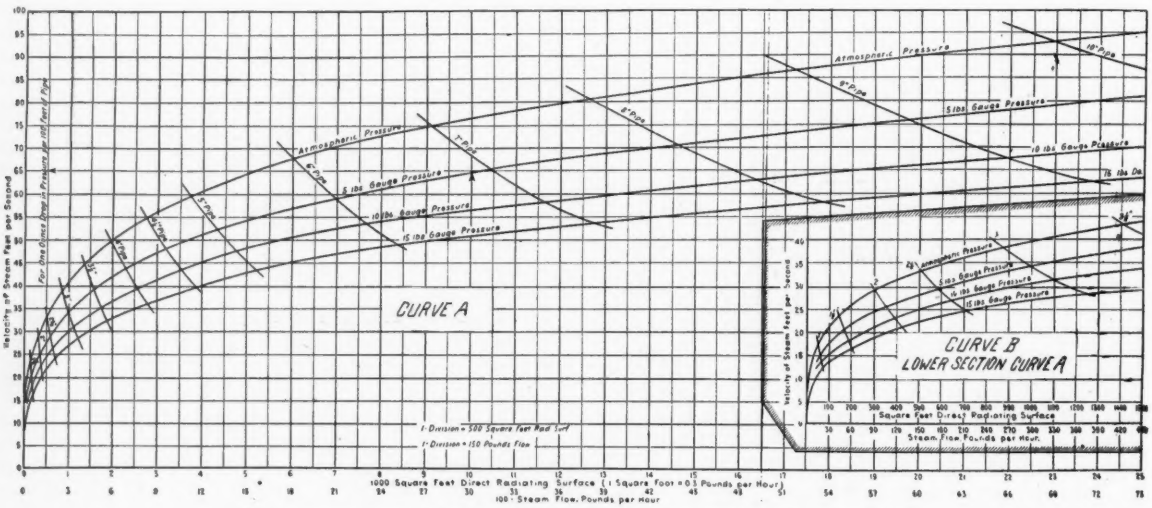
Velocity of Steam Feet per Second
Atmospheric Pressure
5 lbs Gauge Pressure
10 lbs Gauge Pressure
15 lbs Gauge Pressure
CURVE A
CURVE B
LOWER SECTION CURVE A
1000 Square Feet Direct Radiating Surface (1 Square Foot = 0.3 Pounds per Hour)
100 - Steam Flow, Pounds per Hour
Square Feet Direct Radiating Surface
Steam Flow Pounds per Hour

FIG. 2. CURVES FOR DETERMINING THE SIZE OF STEAM-HEATING MAINS

In addition, a pressure-reducing valve taking steam from the high-pressure service should be installed for emergency as when the exhaust is insufficient to meet demands during severe weather or may be entirely unavailable. This also should be provided with bypass and cutout valves.

The exhaust line to the heating system should be provided with a large oil separator placed next to the main system control valve and fitted with either a water seal or a trap in the sewer discharge.

The mains with their connecting branches must have a uniform pitch of about 1 to ¾ in. in every 10 ft., and wherever possible, should feed the radiators by means of the "overhead" or "down-feed" principle. Where

necessary to make a reduction in size, eccentric fittings only should be used and, if necessary to pass obstructions resulting in the formation of pockets, drips should be provided at such points.

A pitch of 1 in. in every 30 ft. will prove satisfactory for wet or dry returns.

Horizontal branches feeding risers should be no longer than about 30 in., thus necessitating carrying the mains from 2 to 3 ft. from the basement walls if the radiators on the upper floors are to be placed along outside walls. Where risers are of considerable length, expansion loops should be provided every 5 or 6 stories.

Returns generally terminate in some form of drip receiver, whence they are returned to the boilers or delivered to the feed-water heater by means of a pump, ejector or condenser. The speed of the pump, if such is employed, may be controlled by a vacuum governor mounted on a bypass of the steam supply line of the pump with a connection to the return main carrying a vacuum gage.

In the vacuum system illustrated in Fig. 1, an air separating tank is employed between the vacuum pump

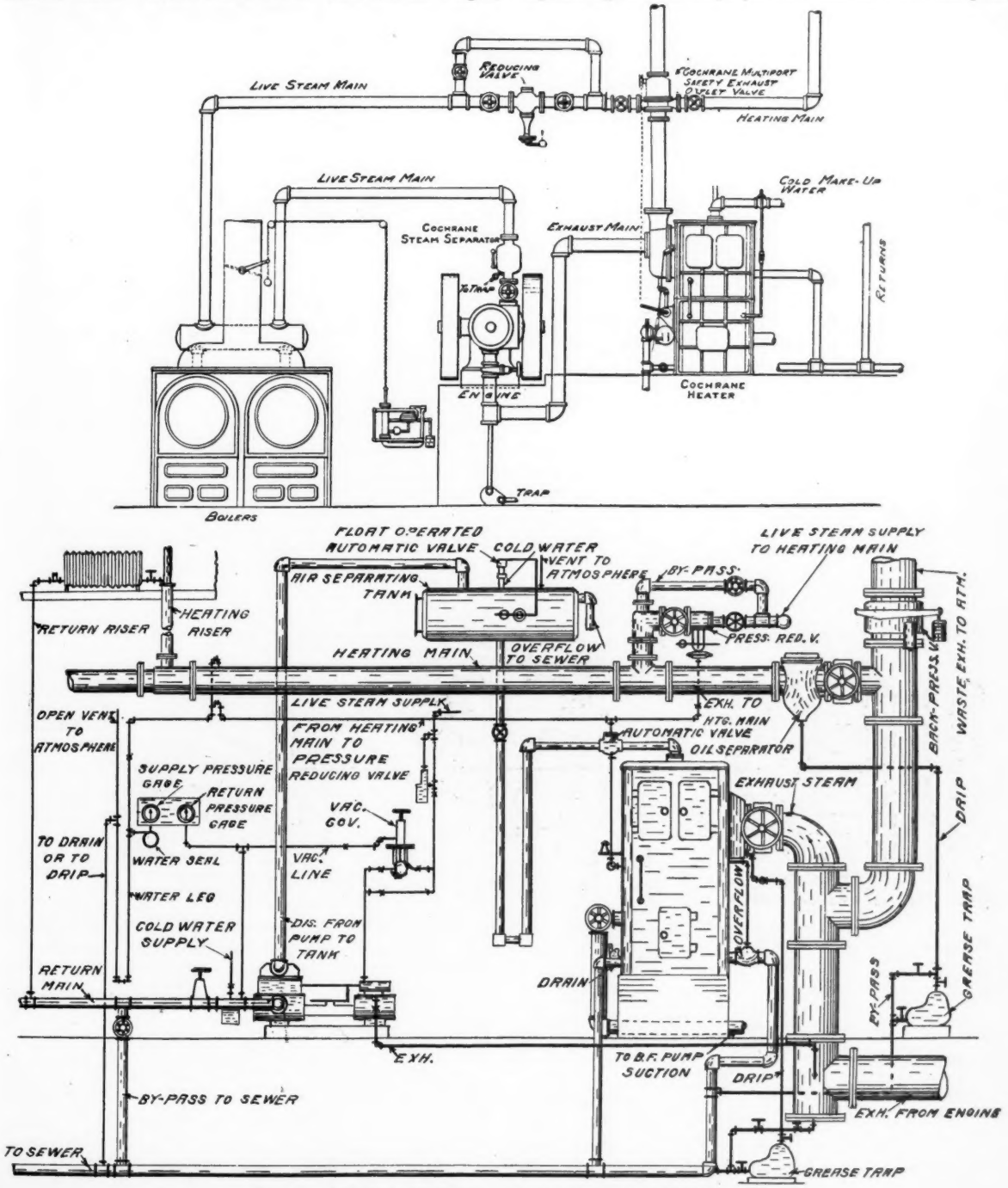


FIG. 1. TYPICAL EXHAUST STEAM HEATING CONNECTIONS

and heater. This is provided with a vent open to the atmosphere, an overflow to the sewer and an automatically-operated float valve for the control of makeup water which may be introduced at this point of the system. Directly below this tank is a water seal preventing the escape of steam from the heater.

### Size of Mains and Returns

Required size of steam heating mains may readily be determined by means of the curves shown in Fig. 2, presented by A. L. Johnston, Jr., in a recent issue of The Engineering Magazine.

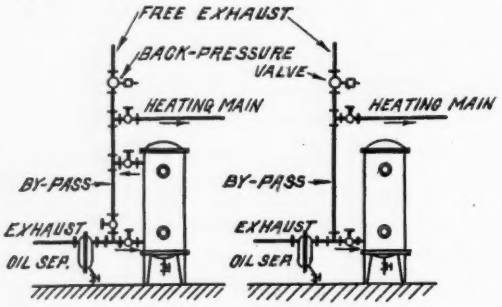


FIG. 3. EXHAUST STEAM CONNECTIONS FOR OPEN AND CLOSED HEATERS

Assume we have a heating system to be operated at 5 lb. pressure and containing 10,000 sq. ft. (3000 lb. steam per hour) direct radiating surface, and that the required size of supply main is desired; allow a pressure drop of 1 oz. per 100 ft. of straight smooth pipe. At 10,000 sq. ft. radiating surface on the horizontal axis, read vertically upward to the 5 lb. pressure line; this is intersected between the 6 and 7-in. pipe-diameter line, therefore requiring the use of a 7-in. pipe. Reading from this point to the velocity axis at the left, the approximate velocity is found to be 65 ft. per sec., as indicated by the arrow.

To find the size of return mains, allowing a pressure drop of 1 oz. per 100 ft., divide the number of square feet direct radiating surface by the constant in the following table corresponding to the per cent of steam in returns and refer the equivalent radiation so found to curve A or B, Fig. 2.

| Wet Steam | 2½% Steam | 5% Steam | 7½% Steam | 10% Steam | 15% Steam | 20% Steam | 25% Steam |
|---|---|---|---|---|---|---|---|
| 40 | 20 | 13.33 | 10 | 8 | 5.71 | 4.44 | 3.64 |

If, in the above problem, it is required to determine the size of return mains and 10 per cent steam is necessary to maintain dry returns, we find, using constant 8 in the above table, that the equivalent radiation is equal to 10,000 divided by 8, or 1250 sq. ft.

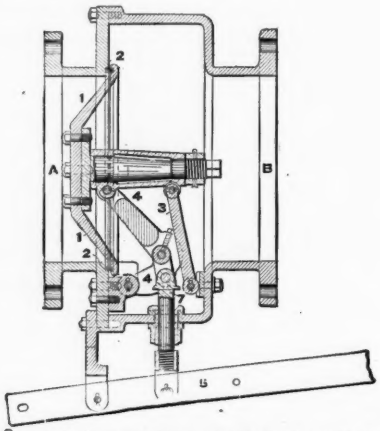


FIG. 8. SECTION FOSTER FREE EXHAUST VALVE

Referring to curves A or B, Fig. 2, at 1250 sq. ft. radiating surface and reading upward to the atmospheric pressure line, we find the intersection of these between the 3 and 3½-in. pipe line, thus calling for a 3½-in. return.

### Vacuum Pumps

The required size of vacuum pump may be readily determined by the use of the accompanying table of the Warren Webster Co. Use the nearest value of F corresponding to the sum of (the number of square feet of radiation) plus (number of units times 100).

Assume it is desired to find the required size of pump for an installation of 150 radiators having a total of 5000 sq. ft. of direct radiation; $5000 + (150 \times 100) = 20{,}000$; referring to the table we find the nearest to this 19,390, corresponding to a 5 by 6 by 10-in. pump having a ¾-in. steam, 1-in. exhaust, 4-in. suction, and 3-in. discharge.

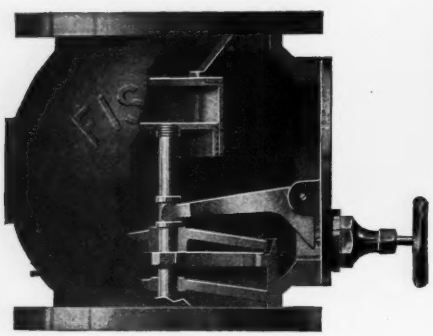

FIG. 4. SECTIONAL VIEW FISHER AUTOMATIC EXHAUST RELIEF VALVE

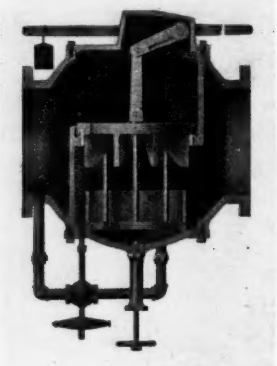

FIG. 5. DAVIS AUTOMATIC COMBINATION BACK PRESSURE AND RELIEF VALVE

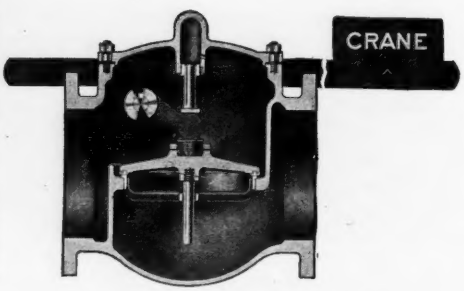


FIG. 6. CRANE COMBINATION BACK PRESSURE AND EXHAUST RELIEF VALVE

### Indirect Coils

While wrought pipes are largely used for these, within recent years cast-iron heaters have been adopted. Where wrought coils are used with steam as the heating medium, they should be made up of short rather than long lengths, as these are never effectively drained of condensation when the temperature difference is great owing to the existence of a partial vacuum towards the end of the coils.

### Heater Connections

If possible, the main exhaust should drain to the heater; but if this cannot be done, due to the exhaust-line being considerably lower than the heater, proper drainage may be accomplished by means of an entrainer similar to that frequently employed in connection with the riser of a barometric or elevated jet condenser, or

Sizes and Capacities of Vacuum Pumps

| Size | Steam In. | Exhaust In. | Suction In. | Discharge In. | F |
|---|---|---|---|---|---|
| 4 x 5 | 3/8 | ... | ... | ... | 6830 |
| 4 x 4 x 6 | 3/8 | 1/2 | 2 1/2 | 2 | 7270 |
| 4 x 4 x 8 | 3/8 | 1/2 | 2 1/2 | 2 | 8000 |
| 5 x 5 | ... | ... | ... | ... | 10680 |
| 4 x 5 x 6 | 3/4 | 1/2 | 3 | 2 1/2 | 11353 |
| 4 x 5 x 8 | 3/8 | 1/2 | 3 | 2 1/2 | 12500 |
| 4 1/2 x 5 1/2 x 8 | 1/2 | 3/4 | 3 | ... | 15125 |
| 6 x 5 | ... | ... | ... | ... | 15990 |
| 6 x 7 | ... | ... | ... | ... | 17215 |
| 4 1/2 x 6 x 8 | 1/2 | 3/4 | 3 | 2 1/2 | 18000 |
| 5 x 6 x 10 | 3/4 | 1 | 4 | 3 | 19390 |
| 7 x 7 1/4 x 10 | 1 | 1 1/4 | 5 | 4 | 28256 |
| 6 x 7 1/2 x 12 | 3/4 | 1 | 5 | 4 | 30605 |
| 7 x 8 x 16 | 1 | 1/4 | 5 | 4 | 34470 |
| 6 x 8 x 12 | 3/4 | 1 | 5 | 4 | 36620 |
| 9 x 10 | ... | ... | ... | ... | 43627 |
| 8 x 9 1/4 x 12 | 1 | 1 1/2 | 6 | 5 | 48957 |
| 8 x 10 x 12 | 1 | 1 1/2 | 6 | 5 | 57220 |
| 10 x 14 | ... | ... | ... | ... | 60250 |
| 10 x 12 x 12 | 1 1/4 | 1 1/2 | 6 | 5 | 82997 |
| 10 x 16 | ... | ... | ... | ... | 30713 |
| 14 x 16 | ... | ... | ... | ... | 122500 |
| 12 x 14 x 20 | 1 1/2 | 2 | 10 | 8 | 133000 |
| 16 x 16 | ... | ... | ... | ... | 161270 |
| 14 x 16 x 20 | 2 | 2 1/2 | 12 | 10 | 173720 |
| 16 x 18 x 20 | 2 1/2 | 3 | 12 | 10 | 219870 |
| 18 x 24 | ... | ... | ... | ... | 233640 |
| 18 x 20 x 20 | 3 | 3 1/2 | 14 | 12 | 271440 |

by means of a trap as in Fig. 1. An oil separator placed directly ahead of the entrainer will care for all oil carried over by the exhaust; many heaters of the open type are provided with an oil separator built integral, in which case the first separator is necessary only in connection with heating systems.

In the case of the induction type of open or closed heater, Fig. 3, the closing of a valve placed at the steam inlet, will cut the heater out of service for cleaning and repairs. With a through heater a bypass fitted with the necessary cutout valves will allow all or any portion of the steam to be diverted as conditions may require.

One pound of exhaust steam in condensing gives up approximately 1000 B.t.u. If, therefore, the initial temperature of the feed water is 50 deg. F., and the final temperature 210 deg. F., the engine is furnishing 1000 ÷ (210 — 50), or 6.25 times the quantity of steam required to heat the feed water to a maximum. It is, therefore, evident that the valve in the bypass of a through heater may be opened sufficiently to divert the required amount of steam through the heater. From a theoretical con-

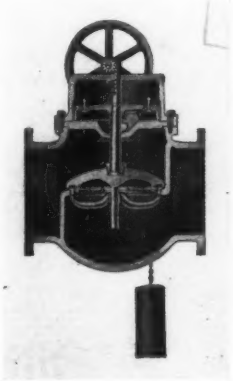

FIG. 7. SECTIONAL VIEW JENKINS BROS. BACK PRESSURE VALVE

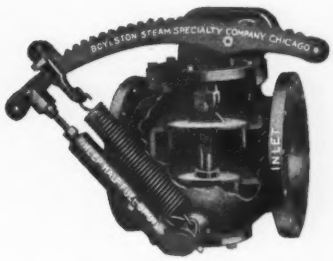


FIG. 9. BOYLSTON UNIVERSAL PATTERN NOISELESS BACK-PRESSURE VALVE

sideration, therefore, heater inlet and outlet fittings need be but 1/6 the size of that in the bypass; for all practical purposes, however, it is desirable to make these 1/2 the size of that in the bypass. This reduction in size may prove to be a considerable item in large installations.

### Condensers

In independent condensing systems, the condenser should be placed below and as near the engine or turbine as possible, in order to allow the exhaust steam to gravitate toward it. Bends and joints should be reduced to a minimum to decrease friction and the possibility of air leakage and where a change in direction of the piping is necessary only long-sweep bends of cast iron or steel should be employed.

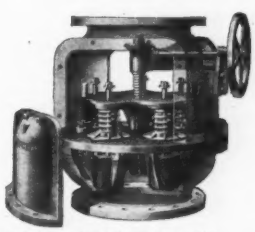

FIG. 10. SCHUTTE FREE EXHAUST VALVE

FIG. 11. COCHRANE MULTIPORT EXHAUST VALVE

Local conditions may necessitate placing jet or surface condensers on the same level as or above the engine or turbine, requiring the use of additional piping. In this case, the lowest point of the exhaust should be fitted with a drip which should be open whenever the engine is not operating. Centrifugal condensers like those of the ordinary jet type are preferably connected as directly and closely as possible to the engine or turbine.

In high vacuum systems, for steam-turbine practice, the turbine is mounted directly over the condenser, the steam connections being joined by a short copper corrugated expansion joint.

Barometric condensers due to being, as a rule, installed at a considerable height, require the use of an exhaust riser which should be joined to the horizontal exhaust line by means of an extrainer. The exhaust line should be given a pitch of about 1 in. in every 20 ft.

One of the most important precautions required in the design of condensers of the jet type is to place the exhaust steam inlet some distance above the point of injection water discharge so as to avoid the possibility of flooding the engine or turbine. The diameter of the steam-inlet pipe *required to carry the steam to the condenser may be found by multiplying 0.175 by (the square root of the quotient from dividing the weight of steam flowing in pounds per minute, by the density of the steam in pounds per cubic foot).

Exhaust line leaks are generally accompanied and indicated by poor vacuum and may readily be located by going over all joints with a small flame, such as that of a tallow candle, and noting the points at which it is drawn in; leaks may also be found in the body of the exhaust line in the form of casting blow holes. Joint leaks may be eliminated by taking up on the joint or repacking it, after which while the condenser is in operation go over the entire joint or joints, or other spots where small leaks may have been noticed with a good grade of black paint or shellac. This, due to the action of the vacuum, will be drawn into the tiniest holes and stop the leak. Blow holes of any considerable size require drilling and tapping of the castings and the insertion of the proper size pipe plug made air tight by the use of white lead.

*The weight of steam flowing in pounds per minute is equal to the maximum steam consumption of the engine or turbine used in connection with the condenser. The value of density is obtained from a steam table for the average pressure to be carried in the condenser.

# Oil Piping

VARIOUS PIPING SYSTEMS FOR HANDLING OILS USED ABOUT POWER PLANTS

OIL MAINS may be divided into 3 classes: Engine oil supply, cylinder oil supply, and oil drip mains. The engine oil mains, which are continually under pressure, are used in connection with a drip return system.

Brass pipe is generally to be avoided, wherever possible, as it increases the cost of installation, and brass joints are difficult to make tight. Galvanized pipe is suitable, as this pipe must be of good grade to be galvanized, and in the process the pipe is pickled, which removes most of its scale. Malleable iron fittings should not be employed, as they are not stiff enough ordinarily to make up oil tight joints. Heavy cast-iron fittings and galvanized pipe or drawn steel tubing and brass fittings make the best combinations.

Care should be taken to locate the piping in a warm place so that the flow of oil will not become sluggish in cold weather.

## STORAGE TANKS

IN MAKING proper provision for oil storage, it is necessary to consider whether it is advantageous to receive the oil in carload lots, amount of storage room available, underwriters requirements, facilities for emptying the barrels, etc.

Figure 1 shows 3 storage tanks with a receiving sink located outside of the building, this sink being provided with waste or other filtering material to prevent impurities from reaching the storage tank. Oil flows by gravity to the tanks, the tops of which are placed at a level below that of the receiving sink.

In considering the use of water or air to raise oil, it must be noted that the storage tank may require a large volume of air to raise 1 cu. ft. of oil into the supply or measuring tank. Water would be quicker to act; but if water were employed, special care would have to be exercised to avoid the possibility of destructive pressure being placed on the storage tank. The use of water introduces a feature which might cause serious oil loss, due to the fact that water employed to raise the oil must be run to the sewer whenever the storage tank is to be filled. Unless closely watched, all of the water might run out and considerable oil might be wasted to the sewer.

## SUPPLY TANKS

FREQUENTLY, it is necessary to install one or 2 elevated supply tanks, from which the oil is fed by gravity to the various bearings. These tanks should be properly vented, and where more than one tank is employed, they should be interconnected. In order to avoid long and complicated pipe mains, these tanks should be located

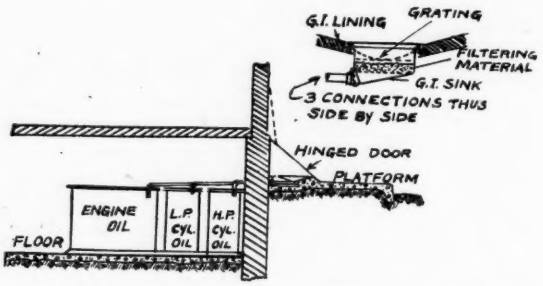


FIG. 1. STORAGE TANKS AND RECEIVING SINK

near the center of the plant if possible. Figure 2 shows a gravity supply tank and its connections as employed in the Bowser type 2F oiling system.

One of the methods for placing cylinder oil under pressure and delivering it to the steam machinery which is to be lubricated is shown in Fig. 3. The necessary pressure is maintained here by adding to the steam pressure the weight of the water in a condensation pipe. The principle employed is similar to that of the standard sight-feed lubricator so commonly used. Two supply tanks are used, so arranged that one may be shut off

from the system while being filled from the supply barrel and the other continue to furnish oil for the system.

### Oiling Connections to Bearings

Connections to main journals, eccentrics and crankpins should be arranged so that the journal cups or oil guards can be removed while running and without shutting off the oil supply. This requirement is provided for with the arrangement shown in Fig. 4, in which the pipes swing on threaded joints. If valves are employed at each of the swing connections, they are placed at A, this being necessary in order to disconnect the cups from the journals. Valve B is the throttle, and tee shown at C is pointed down, with a valve or plug at its lower end.

Possibly the most commonly used style of oil cup is the regular pattern sight-feed glass oil cup with the

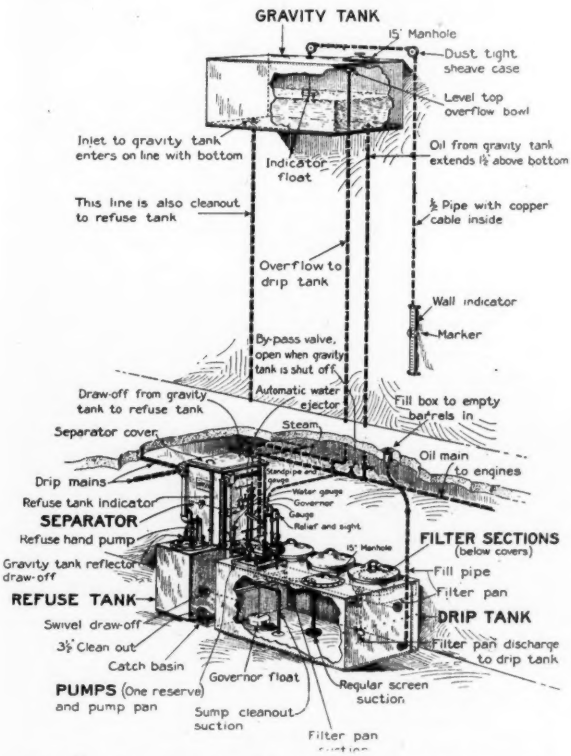


FIG. 2. GRAVITY SUPPLY TANK AND CONNECTIONS

hole drilled in the top for a pipe nipple to attach the oil piping to the cup. A valve is placed in the line to the cup for regulating the flow to the cup the same as the regulated flow from the cup to the bearing. A second style is that of the closed glass-body pressure cup with one hand regulating valve, which requires less attention than the first style, and which can be filled by hand by closing the valve in the supply pipe and removing the plug.

Another type of pressure oil cup has a hand regulating valve which can be set for the desired feed, so that when shutting down the machine and turning over a cam or other device, the oil flow is stopped, but the adjustment for feeding is retained. A cup of this style is shown in Fig. 5, in which the feed is regulated by the milled nut, R, and when once set it can be locked by jamb nut O. To stop the flow of oil the cross bar, C, is given a quarter turn to the right or left, dropping it into a deep slot. To start the feed again this operation is reversed.

Intended for emergencies to supply oil used in connection with sight-feed lubricators is a hand oil pump, one form of which is shown in Fig. 6. This particular plunger pump is made so that it can be attached either vertically or horizontally by transposing plug B and shank A, which are interchangeable. As shown in the cut, it is arranged for a vertical connection.

### Returns to Filters

Various oil drains from the engine may be attached to a drip pot located in the main, as this will avoid the necessity of running many branches. No drip branch should be installed that cannot be cleaned from end

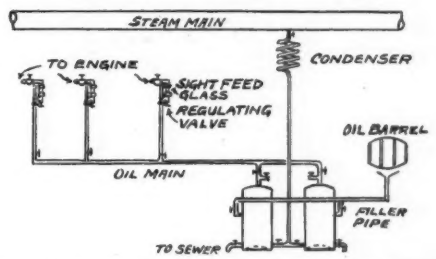


FIG. 3. SUPPLY TANKS FOR PRESSURE SYSTEM

to end by passing a wire through it. For basements where the drips are located close to the ceiling, the drip pot shown in Fig. 7 is suitable, while that shown in Fig. 8 is adaptable for drip lines built in the concrete floor. These drip pots are of size to take 6 or 8 drains, one pot to take 3 or 4 drains at one point and discharge into the next pot, which takes 4 or 5 more and discharges into another. Each engine has possibly 3 pots, including the one located in the main, and when pots are employed there is no occasion to use valves in the branches or other means for cleaning except by wire from pot to pot.

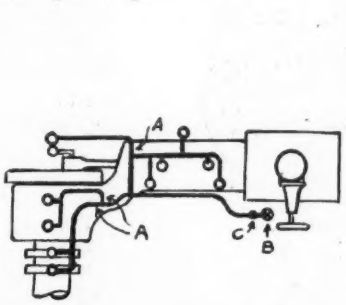

FIG. 4. JOURNAL OILING CONNECTIONS
FIG. 5. SIGHT-FEED OIL CUP

Return pipes leading the oil from the various bearings or collecting pans to the filtering tank may be either wrought or cast-iron; the former is preferable, however, for small pipes. To secure a good gravity flow for the oil, the pipes should be pitched at least 1 in. in every 10 ft. Where many returns are connected to one common header, provision is usually made for the

removal of air by placing ½-in. or ¾-in. vent pipes on the header. These vents must extend above the highest point in the return piping, so that if the pipe discharging to the filter should become plugged, the oil will not escape through the vents. To facilitate cleaning of the pipe, it is good practice to install crosses instead of tees in the header, one leg being plugged.

FIG. 6. HAND OIL PUMP

Shown in Fig. 9 is a top view of a representative form of oil filter designed for a gravity system by the Elliott Co. Oil returning from the engines enters the filter through the pipe connection, 21, and empties into the strainers, 2, which are suspended in the water separating chamber. In this chamber, the oil and water are separated, the water settling to the bottom where it is automatically discharged, and the oil upon rising to the top passes into the heating chamber, 16, where it is heated by the coils, 7. Leaving the heating chamber, the oil travels around the treating chamber, 3, until it reaches the inlet, 15, to the filter bags, 6, which remove the insoluble impurities not precipitated in the treating chamber, and the clean oil drops into the clean-oil reservoir.

Impurities from the treating chamber are flushed out through connection 13, and condensation from the heating coils escapes through trap 12. Connection 22 is attached to the gage glass which indicates the height of water in the separating chamber and connection, the gage indicating the amount of oil in the clean-oil chamber, and 20 is the automatic water discharge.

Figure 10 shows the piping arrangement of this automatic water discharge. Water enters through the connection at A, and, due to the head of the oil, is forced up pipe B, through C and up D until it overflows into the outlet pipe, E. The outlet pipe is adjustable and may be moved up or down, according to the specific gravity of the oil being handled, and the height of the water in the gage glass, G. When once properly adjusted, it can be locked in position by the lock nut, F.

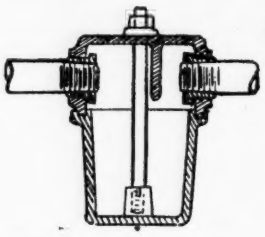

FIG. 7. CEILING DRIP POT

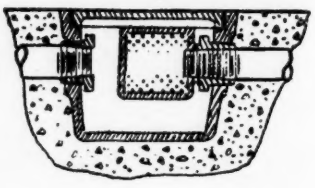

FIG. 8. FLOOR DRIP POT

## PUMPS AND RETURNS TO SUPPLY TANK

IN FIG. 11 are shown the pump and connections employed in the Bowser type 4F gravity oiling system which is somewhat smaller than the system shown in Fig. 3. This pump, which may be driven by steam or air, is 2½ by 1⅜ by 2 in. in size and brass fitted for oil.

Steam is supplied through a ¼-in. line and exhaust through a ⅜-in. pipe. After being drawn up through a ¾-in. suction, the oil is forced through a ½-in. line to the supply tank, from which a ¾-in. pipe conveys it by gravity to the points of lubrication.

To facilitate in pumping out the washings from the drip tank, a ½-in. plugged opening is provided on one side of the discharge cylinder. When the gravity tank is out of service, the bypass in the discharge line may be opened and the oil pumped direct to the journals.

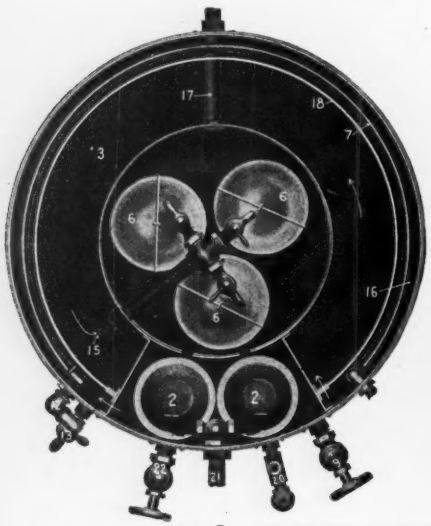


FIG. 9. OIL FILTER CONNECTIONS

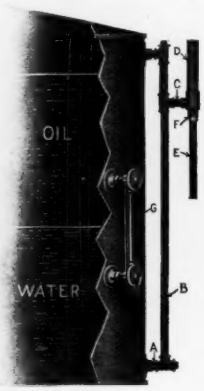


FIG. 10. AUTOMATIC WATER DISCHARGE FOR FILTER

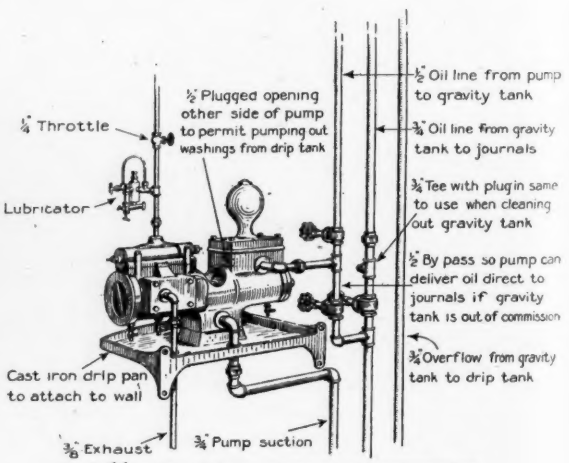
¼ Throttle
½ Plugged opening other side of pump to permit pumping out washings from drip tank
½ Oil line from pump to gravity tank
¾ Oil line from gravity tank to journals
¾ Tee with plug in same to use when cleaning out gravity tank
Lubricator
½ By pass so pump can deliver oil direct to journals if gravity tank is out of commission
¾ Overflow from gravity tank to drip tank
Cast iron drip pan to attach to wall
⅜ Exhaust
¾ Pump suction

FIG. 11. OIL PUMP PIPING ARRANGEMENT

### Hydrostatic Lubrication

For the lubrication of cylinders, a hydrostatic lubricator of the sight feed type, as shown in Fig. 12, is commonly employed. To operate, the lubricator is filled with oil by removing cap K, the height of oil appearing in glass L. If water is present the oil floats on top, as indicated; after the cap is screwed in place the valves in the condenser pipe are opened, subjecting the oil in the vessel to steam-pipe pressure. Steam is condensed in pipe C, filling tube B and part of C, thus adding to the steam pressure the pressure due to the weight of the water column. Valve F, which communicates with the top of the vessel by means of tube A, is opened wide as is also the regulating valve, I. The pressure at B being greater than that at A by the amount equivalent to the height of the water column, forces the oil through A and the "sight feed," S, to the steam pipe. The rate of flow is controlled by regulating valve I. As the oil flows from the vessel, its space is occupied by condensed steam.

It is very important in the operation of sight-feed lubricators that they be properly connected. Many engines are using more oil than is necessary, for the reason that the lubricator is improperly attached.

In connecting up a lubricator, its oil discharge shank should be attached to a nipple having a running thread, which should be screwed into the steam pipe so that the end will project clear through into the center of the steam pipe. If the shank is simply screwed into the pipe or the throttle casing, it will probably not project clear through and a very large percentage of the cylinder oil will spread out over the interior surfaces of the steam pipe, throttle valve or steam passages.

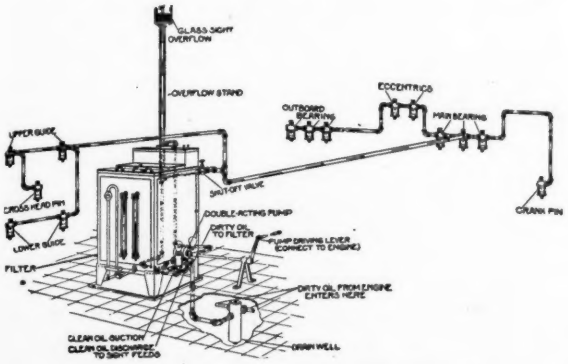


FIG. 14. INDIVIDUAL OILING SYSTEM

A condensation pipe of sufficient length should be attached above the lubricator to insure weight of water to displace the oil and force it up to the sight-feed glass; in ordinary practice, a length of from 12 to 18 in. is sufficient.

Owing to the small capacity of this lubricator, it must be refilled frequently and to reduce the amount of labor required with the above apparatus, independent sight feeds are sometimes used in connection with a central reservoir. In such an installation the condenser pipe leading from the steam main enters the bottom of the reservoir and the condensed steam fills up the reservoir as fast as the oil is fed out.

### Gravity Oiling Systems

In central gravity oiling systems the oil is pumped into elevated tanks and then conveyed by gravity through a system of pipes to the bearings, from which it is collected and run also by gravity to an oil filter located at some lower level than the engines. The filtered oil is again pumped to the overhead tank and is thus used over and over again, thereby effecting a considerable saving in the amount of oil used. Oil feeds used in this system are usually fed either from the central oiling system or from the sight-feed cup itself, which may be filled by hand.

Figure 2 shows the Bowser 2F type system, which is representative of a central gravity oil filtering and circulating installation. One pump lifts the oil from the drip tank to the gravity supply tank from which there is a gravity flow to the engines and gravity flow to the drip main running to the separator, and from the separator down the standpipe to and through the filters to the drip tank. In an emergency, the bypass valve in the oil main may be opened, thus cutting off the supply tank and pumping the oil direct to the engines.

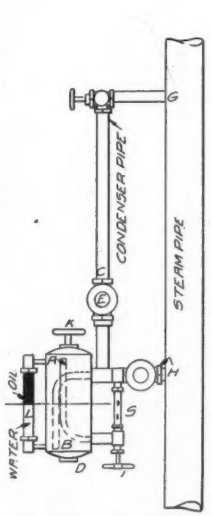


FIG. 12. SIGHT-FEED HYDROSTATIC LUBRICATOR

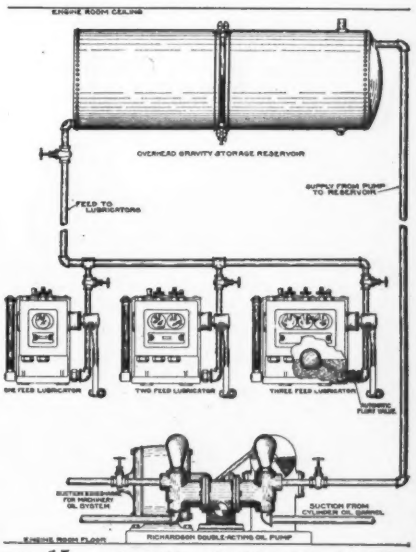


FIG. 15. CENTRAL SYSTEM FOR FORCED-FEED LUBRICATORS

### Forced Feed Lubricators

Consisting of an oil reservoir fitted with a pump attached to some moving part of the engine so as to supply a definite quantity of oil with each stroke of the engine, a forced-feed lubricator supplies a feed which is uniform, and independent of the pressure pumped against. The rate of feeding is determined by the length of the stroke of the pump piston, which is easily adjustable.

Figure 13 shows a typical form of individual forced-feed lubricator with a single feed, although multi-feed lubricators are also used extensively.

Shown in Fig. 14 is a drawing which diagrammatically illustrates the principle of operation of a Rich-

ardson individual oiling system. Used oil from the 14 lubricating points of this particular installation is collected in a cast-iron drain well which is located low enough so that the oil will flow to it by gravity. From this drain well the dirty oil is taken up and elevated by one end of a double-ended plunger pump, attached to the filter base, and discharged into the top of the filter.

After passing through the filter, the purified oil is taken away by the opposite end of the pump and is delivered through a system of piping on the engine or machine and conveyed to the various sight-feed oilers which are located at the points of lubrication.

To smooth out the pulsations of the pump, which is also provided with air chambers, and to maintain a constant uniform oil pressure to the sight-feed oilers,

FIG. 13. FORCED-FEED LUBRICATOR

a glass overflow stand, the top of which is slightly above the highest point of lubrication, is connected into the discharge pipe from the pump.

This stand consists of 2 concentric pipes, and the outer pipe is connected directly to the pipe supplying the oilers. The controlling valve, which is connected in the supply pipe, is set so that the pump will deliver the required amount of oil to the oilers and show a level of oil in the glass sight overflow reservoir, any excess oil overflowing down through the inner pipe and back into the filter. The overflow stand also indicates that oil is being delivered to the system. The top of the glass reservoir is provided with a large opening with a removable cover, into which oil can be poured by hand in case of failure of the pump.

In some large plants where a number of forced-feed lubricators are employed, they are arranged on a modification of the central oiling system as shown in Fig. 15. In this instance, 3 lubricators are supplied by oil from a central overhead reservoir from which the oil flows to the lubricators by gravity; the level of the oil in each lubricator tank being maintained by a float valve.

# Fuel Oil Systems

PIPING ARRANGEMENTS FOR HANDLING FUEL OIL IN POWER PLANTS

FOR the average oil-burning boiler plant of small or medium size, the oil is commonly stored in a cylindrical steel tank similar to that shown in Fig. 1, which is built up of steel plates with dished ends. To prevent flooding of the furnaces or boiler room with oil in case a burner valve is accidentally left open, the supply tank is usually buried in the ground at such a level that its top is below the level of the burner tips.

Location of the storage tanks must be carefully considered in order to conform to the requirements of the underwriters. For example, if the tank should be placed above the ground level, it must be situated at least 200 ft. from inflammable property, so as to minimize the danger to that property in case the oil should catch fire. In a town or city this requirement is often expensive and difficult to meet and the tanks are, therefore, usually placed underground. The requirements for an underground tank are that it must be at least 30 ft. from the nearest building, and that it must be at least 2 ft. below the surface of the ground.

To facilitate filling, the storage tank should be near the railway siding on which the tank cars are run, and

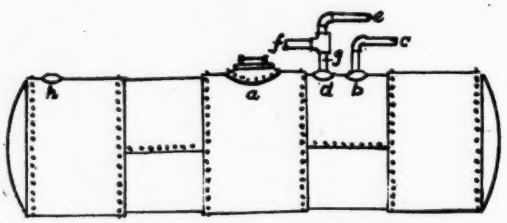


FIG. 1. FUEL OIL STORAGE TANK

at a lower level, so that the oil may flow from the car to the storage tank by gravity. Where the tank is not low enough to permit this method to be employed, the oil may be pumped out of the tank car into the tank, the suction pipe extending into the tank car and the discharge pipe being connected to the filling pipe of the storage tank.

Air pressure has been adopted as a substitute for pump in some instances, and the method by which it is utilized is shown in Fig. 2. Section *a* represents the central part of the tank car, and the pipes *b* and *c* are connected to the dome, *d*. All other outlets from the tank car are closed, and when the compressed air is admitted through *b*, the pressure on the surface of the oil forces the oil up the pipe, *C*, and over into the storage tank.

Common sizes of oil tanks for boiler installations are 8 ft. in diameter by 28 ft. long and 9 ft. in diameter by 33 ft. long. The smaller tank has a capacity of about 10,500 U. S. gallons and the larger tank a capacity of approximately 15,700 U. S. gallons. In either case, a good quality of steel plate 5/16 in. thick should be used and the heads should be made of 3/8-in. plate.

The required capacity of the tank or tanks installed depends upon the size of the plant and the frequency with which shipments of fuel may be delivered. If the plant lies fairly close to the oil fields, so that there is

little delay in obtaining shipments, it is unnecessary to carry a large supply in storage, and a week's supply is usually sufficient. A tank 9 ft. in diameter and 33 ft. in length will hold one week's supply of oil for a plant of 500 boiler horsepower operating 10 hr. a day at an average efficiency of 75 per cent.

No openings should be made in the bottom, sides or ends of the storage tank; such openings as are required should be at the top. The largest opening required is that of the manhole as at *a*, Fig. 1, and this should be fitted with a screw down cover. There must be a flange, *b*, for connecting the suction pipe *c* that leads to the pump, and another flange, *d*, for the overflow pipe, *e*, which leads back from the standpipe or from the pressure pumps. The filling pipe, *f*, by which the oil is run into the tank from the tank car, may be attached by a tee to the overflow pipe and both connected with the tank by the nipple, *g*, and the flange, *d*. There should also be a flange, *h*, to which a ventilating pipe can be connected. If the oil around the end of the suction pipe must be heated so that it will flow readily to the pumps, it will then be necessary to add 2 more flanges for the pipes that convey the live steam and carry off the condensation.

Owing to the penetrative nature of oil fuel, the piping should be carefully installed and all joints made tight. Pipes leading to and from the storage tank are usually permanent and the joints may be made up with a cement of litharge and glycerine to insure tightness. Wherever possible, elbows should be avoided in oil piping, as the foreign matter in the oil will collect at these fittings and eventually clog the pipe. It is preferable to employ bends of long radius instead of elbows, and also advisable to arrange the piping in such a way that the oil can be turned off and live steam forced through the oil lines to loosen the deposits of asphalt or carry matter and blow them out.

### Pumping and Heating of Fuel Oil

In every fuel oil installation, pumps must be provided to draw oil from the storage tanks and deliver it to the burners under pressure.

To insure a steady pressure of oil at the burners, the standpipe arrangement shown in Fig. 3 is perhaps the most simple. Oil is drawn from the storage tank through the suction pipe by the pump, *b*, and discharged through the pipe, *c*, into the standpipe, *d*, which is constructed of 4-in. pipe and of sufficient height to give the desired pressure at the oil burners. An overflow pipe, *e*, one or 2 sizes larger than the discharge pipe, *c*, is connected near the top and is carried back to the storage tank. The speed of the pump is regulated so that the amount of oil delivered is somewhat in excess of that used by the burners, thus maintaining a constant level of oil in the standpipe near the overflow outlet. All excess oil flows back to the storage tank through the pipe, *e*, and as the height of the oil column remains constant, the pressure in the oil main, *f*, which leads to the burners, is constant.

Pipe *g* is an extension of the standpipe that serves as a trap for water and sediment contained in the oil. These impurities, being heavier than the oil, fall to the bottom of *g*, and may be blown out at intervals through the pipe, *h*. A vent cock, *i*, is added to the top of the standpipe to allow the release of gas that enters with the oil and collects above the column.

With the standpipe arrangement, a considerable quantity is stored at a point above the level of the burner outlets; consequently if a burner should be carelessly left open when out of service, the furnace would be flooded with oil. Because of this, some insurance companies refuse to insure plants in which the oil is fed by gravity. This danger of flooding, however, may be overcome by the use of a safety device.

Another method of maintaining a uniform pressure of oil is to employ a duplex feed pump and attach on the discharge pipe a relief valve set to open when the desired pressure is exceeded. A side view of such an apparatus is shown in Fig. 4 in connection with a longitudinal section of an oil heater. Leading direct from the storage tank in the suction pipe, *b*, of the duplex pump, *a*, and the discharge from both sides of the pump is led through the pipe, *c*, to the heater, *d*. The air chamber, *e*, and the relief valve, *f*, are connected with

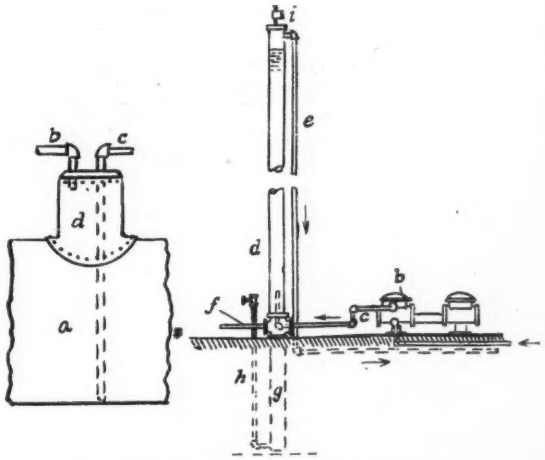


FIG. 2. ARRANGEMENT FOR EMPTYING TANK CAR
FIG. 3. STANDPIPE TO OBTAIN CONSTANT OIL PRESSURE

the discharge pipe through a cross. The air chamber cushions the intermittent discharges of oil and prevents shocks, and the relief valve, which is merely a spring-loaded valve, is set to the pressure desired at the oil burners. As soon as the pump supplies too much oil, and this pressure is exceeded, the valve rises and the excess of oil is returned to the storage tank by a pipe connected at *h*. Two small pipes lead from the tops of the discharge chambers to the overflow pipe and are fitted with valves *i* to allow the removal of any gas collected in those chambers.

Governor *j* on the steam line, *k*, to the pump automatically regulates the speed of the pump. This governor consists of a flexible diaphragm directly connected to a throttle valve in the steam line. One side of the diaphragm is acted upon by the pressure of the oil in the small pipe, *l*, and the other side by an adjustable spring. When the oil pressure rises too high, the pressure of oil on the diaphragm overcomes the spring pressure and partly closes the throttle valve, thus reducing the pump speed. When the oil pressure has been lowered sufficiently, the spring forces the diaphragm back again, opening the valve and admitting more

steam. By adjusting the tension of the spring, a very uniform speed of the pump may be obtained. The exhaust from the steam ends of the pump flows through the pipe, *m*, to the heater, where it is used to heat the oil. Attached at *n* is a pressure gage to show the oil pressure on the discharge side of the pump.

Heavy crude oils are extremely sluggish and a heater is installed in the system to render the oil more fluid and more easily atomized. In Fig. 4 the heater, which

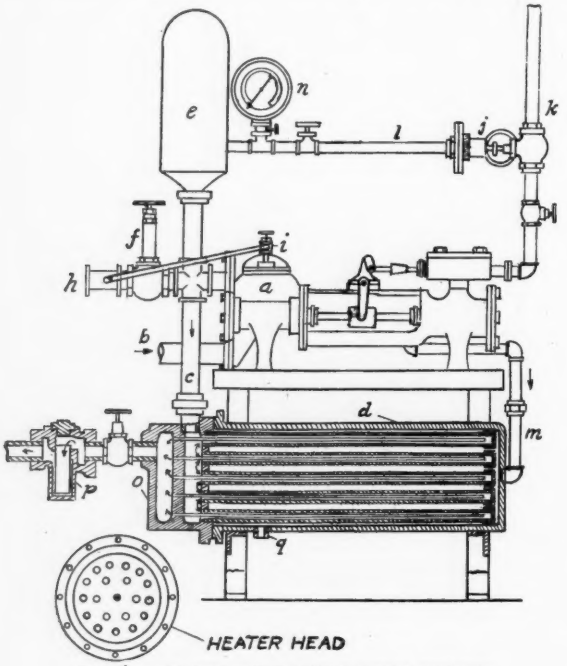


FIG. 4. OIL-PRESSURE PUMP WITH HEATER

is placed between the discharge of the pump and the burners, consists of a cylindrical outer shell, *d*, into which the exhaust steam is conducted by the pipe *m*. The head, *o*, of the heater has 2 compartments and into it are screwed 2 sets of tubes; the larger tubes being closed at one end and fitting over the smaller tubes, which are open at both ends. Oil from the pump

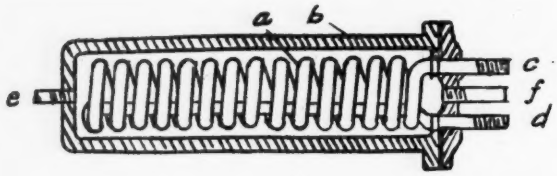


FIG. 5. STEAM COIL FOR HEATING OIL

flows into the inner compartment of the head, then into the larger tubes, around the smaller ones, and finally back through the inside tubes to the outside compartment, from which it passes to the burners through the strainer, *p*. Water and uncondensed steam are drawn from the shell at *q*.

Another heater arrangement is shown in Fig. 5, which consists of a continuous coil that fits closely inside the shell, *b*. Steam enters at *c* and the condensation escapes at *d*, while the oil enters at *e* and is discharged at *f*.

As the heater is subjected to the full pressure of the oil, it should be tested to prove that it is capable of withstanding the maximum pressure. There seems to be no fixed value for the pressure at which oil is delivered to the burners; but in most installations, the pressure lies within the limits of 10 lb. and 50 lb. per sq. in.

## Oil Burners

Two important requirements of a fuel oil burner are: First, that it shall atomize the oil satisfactorily; second, that it may be easily cleaned and repaired. It is almost impossible, even after taking the precaution of cleaning and straining, to prevent dirt from being carried along with the oil, and as a result, clogging of the oil orifices may eventually occur, making it necessary to clean the burner.

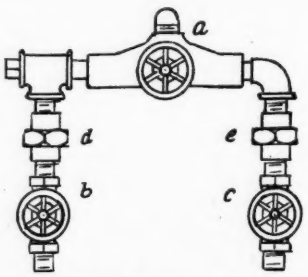


FIG. 6. PIPING FOR GEM OIL BURNER

When installing oil burners, the piping should be provided with unions near the burners to facilitate the work of taking them down for repairs. This arrangement is shown in Fig. 6, which is an installation for a Gem burner. Oil flows to the burner, *a*, through the valve, *b*, and connecting pipe, and steam for atomizing is admitted through the valve, *c*, and the branch to which it is fitted. Unions *d* and *e* make it possible to detach the burner easily. A plug, when removed, allows the connection to be cleaned out. This is accomplished

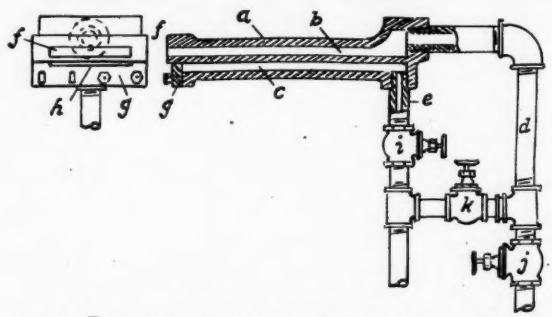


FIG. 7. CONNECTIONS FOR BOOTH OIL BURNER

by closing valve *b* and placing a cap over the end of the burner so that the steam will back up and blow through the oil connection.

One type of fuel oil burner which is employed extensively in stationary-boiler practice is the Booth burner which is shown with pipe connections in Fig. 7. The body of the burner consists of a box-shaped casting, *a*, that is set horizontally and contains 2 passages, *b* and *c*, oil being admitted to *b* through the pipe, *d*, and steam to *c* through the pipe, *e*. Oil flows outward through the wide shallow slot, *f*, at the top of the burner

and drips downward across the end. Bolted across the steam orifice is an adjustable steel plate, *g*, which has a long notch cut in the top edge, forming the outlet, *h*, for the steam, and it is beveled or chamfered on the inside so as to direct the steam upward toward the orifice. The plate may be moved up or down to give the desired depth of slot *h*. Steam escaping from *c* sweeps along the underside of the burner tip and in expanding sprays the oil that runs down from the upper slot.

Steam is supplied to the burner through the pipe, *e*, the flow being regulated by the valve, *i*. In the same way, a valve, *j*, is employed to control the rate of oil flow in the oil line, *d*. Between the oil pipe and the steam pipe is a short connection fitted with valve *k*, which serves as a bypass to admit steam to the oil passage of the burner when cleaning is desired. To accomplish this, oil valve *j* and steam valve *i* are first closed, then valve *k* is opened, allowing steam to rush through the oil passage. The steam passage may be cleaned by removing the plate, *G*, completely and allowing steam to blow through at full pressure. The passages in the burner are straight and fairly large, and there is little danger of their becoming clogged frequently.

# Compressed Air Piping

METHODS OF CONDUCTING AIR TO COMPRESSORS; GOVERNOR CONNECTIONS; TRANSMISSION AND DISTRIBUTING PIPING

PIPING USED FOR CONVEYING air is no different from that for conveying steam; many of the precautions necessary, however, in steam piping are unnecessary in air piping. For example, air is transmitted at practically atmospheric temperature, hence no insulation is used, and expansion and contraction due to changes in temperature are slight, being due only to atmospheric changes. There is always some moisture in air and some provision must be made to withdraw this from the pipe system. This, however, is a simple matter, as a drip from the receiver will usually be sufficient except in long lines when a separator at the motor may be found necessary.

Compressed air at high pressure is difficult to retain and leaks are not always easily located as they are not visible except when submerged in water or painted with soap suds or other liquid.

## INLET TO COMPRESSORS

HIGHEST ECONOMY in compressing air is secured when the inlet air is as cool as may be obtained without artificial cooling. For this reason, the air should be taken as direct as possible from outside the building. The air should be free from dust and intake should be screened to keep out birds, cats, papers, etc., that might give trouble in the compressor.

A common form of intake is shown in Fig. 1 A. It consists of a rectangular galvanized stack erected outside the building wall, the top is covered with a slanting plate which keeps out falling debris and rain, a coarse screen covers the opening which is 8 to 10 ft. above ground in order to avoid the dust that sweeps along the surface. The base of the stack is connected to the intake duct which runs beneath the engine room floor and conducts the air direct to the air compressor intakes.

Where dust is prevalent, the type of intake shown in Fig. 1B is recommended. Here a light framework is built up around a hooded stack. The framework is covered with burlap, which is kept wet by a spray of water from a whirling sprinkler above. The wet burlap catches the dust, which can be easily washed off with a stream of water from a hose. The arrangement also has the advantage of cooling the air before it enters the compressor.

In Fig. 1 C, D and E are shown the common methods of conducting air from the intake duct to the compressor cylinder. It will be noted that the intake duct is considerably larger than the compressor suction pipe and is brought as close to the compressor as possible; these provisions are made in order that the air will enter the compressor cylinders at as nearly atmospheric pressure as is possible.

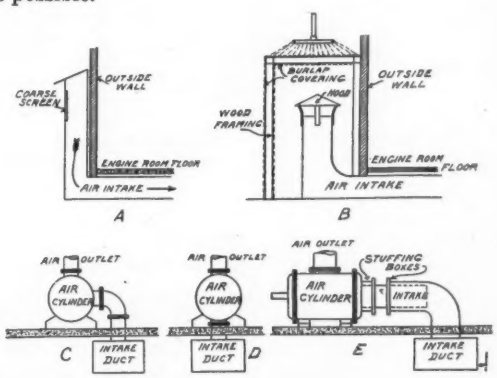


FIG. 1. AIR INTAKE AND SUCTION PIPE ARRANGEMENTS

Intake ducts are made of galvanized metal and all turns are made with long radii to cut down friction. The piping from the duct to the compressor may be of cast or wrought iron and as it is not subjected to pressure may be as light as is consistent for mechanical strength.

## RETURN AIR SYSTEMS

IN SOME kinds of work performed by compressed air, considerable saving in power can be made by returning the exhaust air from the engine to the compressor. In such cases, the piping is special and should be designed for the installation in hand; in Fig. 2, however, 3 diagrams are given showing how air may be returned to the compressor. In the ordinary air engine taking air the full stroke, the used air exhausts to atmosphere from high pressure, thus wasting considerable power. If this is returned to the suction of the compressor as at A,

Fig. 2, it expands against the suction side of the piston helping in the work of compression.

At B, Fig. 2, is shown a diagram of a return air system of displacement pumping, the advantages here are similar to those obtained with the piston type of air engine. When an air-lift well is located near the compressor, the air released at the top of the well may be piped back to the compressor as indicated at C, Fig. 2. When the air is released at the well head it is at practically atmospheric pressure so that the only advantages gained by this system are clean and cold air. To maintain atmospheric pressure in the air duct a screened opening is provided. This will be necessary when the compressor furnishes air for the other purposes than pumping the

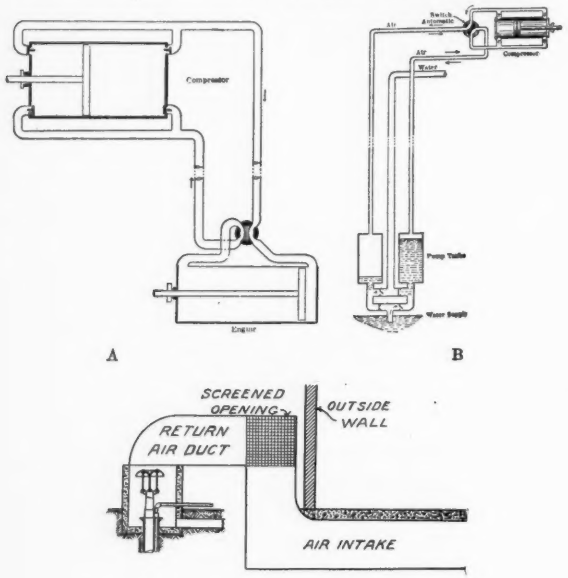


FIG. 2. RETURN AIR SYSTEMS

well, in which case the well would not supply sufficient air for the compressor and a partial vacuum would be formed in the air duct were it not for the opening provided.

### Discharge to Receivers

From the compressor the high pressure air is delivered as directly as possible to the receivers; in case, however, an after-cooler is installed, the air goes first to the after-cooler, then to the receivers. When the air comes from the compressor it is hot and in passing through the after-cooler or the receivers the temperature goes down and usually some moisture is formed; this should be drained off and kept from passing through the transmission pipes with the air.

When an after-cooler is not employed, the receivers are depended upon to radiate the heat of compression and deliver the air to the mains at practically atmospheric temperature; in such cases, several receivers placed in parallel and properly proportioned are preferable to one, as the radiating surface per unit of volume contained in small receivers is greater than with large ones. For cooling purposes, also, the receivers are usually located outside the building. The inlet to the receiver is near the top and the outlet about halfway down; this gives the air a chance to cool and the moisture a chance to settle out of the path of the air before it enters the transmission line. In horizontal types of receivers, baffles are frequently employed to intercept the moisture.

Where one receiver is employed, there should be no valve between the compressor and the receiver; but with several receivers, valves in the inlet and outlet connections give an opportunity for repairs to one receiver without having to shut down the plant. Each receiver should have a pressure gage and a relief or safety valve; this, however, should be located inside the building to prevent freezing of the discharge pipe. A relief valve on the discharge pipe of the compressor is also advisable when there are valves in the inlet connections to the receivers. Figure 3 shows a typical arrangement of compressor and receiver.

### Automatic Control of Compressors

For controlling the air pressure in receivers, several types of devices are employed. The ordinary safety or relief valve placed on the receiver will prevent an over

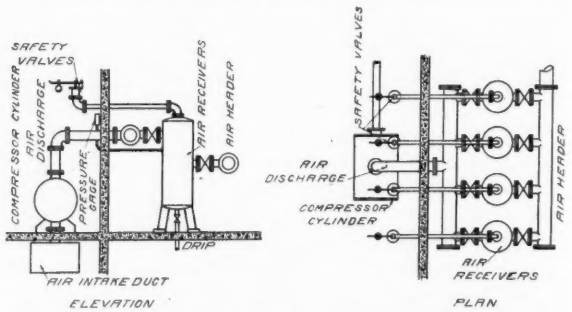


FIG. 3. RELATIVE LOCATIONS OF AIR COMPRESSOR AND RECEIVERS

pressure and is depended upon in some cases, principally temporary installations, as a pressure controller; it controls, however, only the maximum pressure, fluctuations below this depend upon the load carried. The valve is connected directly to the receiver and discharges to atmosphere, thus wasting a great amount of energy.

What is known as an air governor, shown in Fig. 4A, is placed in the discharge pipe of the compressor and opens to atmosphere when pressure in the receiver reaches its maximum allowable; there is, however, a check valve in the discharge line between the governor and the receiver which prevents the waste of air at high pressure. When the governor valve is open, the air passes from the compressor at very low pressure, thus little energy is wasted. A small air pipe from the receiver admits a pressure under a spring and weight loaded piston which, when pressure reaches the maximum desirable, opens a relief valve thus unloading the compressor.

To prevent an excessive speed of steam-driven compressors, a combined speed and air governor is used. Figure 4B is a typical governor for this purpose, the air pressure being transmitted to the governor from the receiver through a small pipe attached to the right. An increase in air pressure causes the steam valve to throttle the steam pressure and decrease the speed of the compressor; the flyball element prevents an excessive speed.

Another device for controlling the air pressure from the steam end of the compressor is shown in Fig. 4C; the larger pipe carries steam to the compressor while the smaller pipe transmits the air pressure from the receiver to the under side of the governor piston. Figure 4D is another form of regulator for the same purpose, but is entirely spring loaded.

### Compressed Air Mains

For ordinary power plant purposes, air mains are of black iron with cast-iron fittings. No entirely satisfactory formulas have been devised for calculating pressure drop in air pipes, but for practical purposes the accompanying table will be found convenient and sufficiently accurate for estimating pipe sizes.

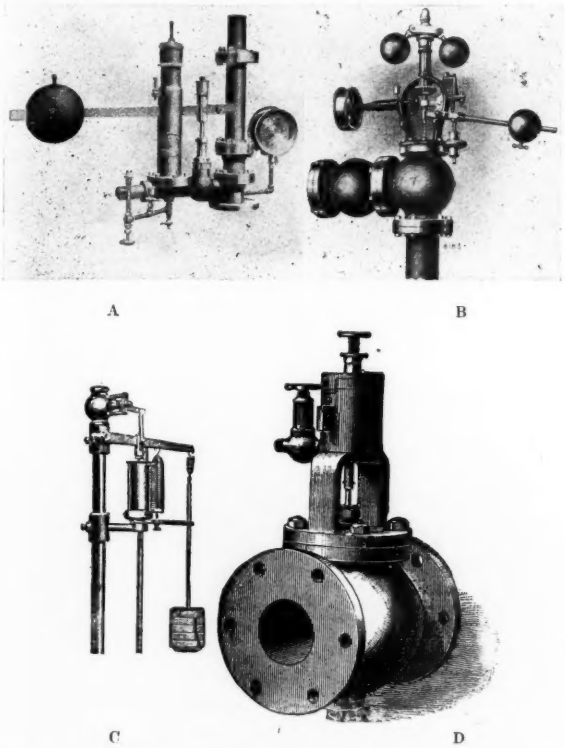


FIG. 4. VARIOUS TYPES OF AIR COMPRESSOR GOVERNORS

In large installations where it is important that no interruptions occur, the loop system is most satisfactory; but for ordinary power plant work, one main with branches and hose connections will be found satisfactory.

Having determined upon the size of pipe for allowable drop in pressure by means of the table or by any other system, the features of the line are similar in nearly all respects to steam piping. Where an after-cooler is employed, the strains are not so great; but provision should be made in long runs for expansion and contraction of the pipe line due to changes in atmospheric temperature. Care should be exercised in the erection of a compressed air line to do away with tees, ells, valves, etc., as much as possible, the rules here being similar to those for steam.

The drop in pressure due to a globe valve is equivalent to the additional length of straight pipe as found by the following rule: Length of pipe equivalent in resistance to one globe valve $= \frac{114 \times \text{diameter}}{1 + (3.6 \div \text{diameter})}$.

The resistance of an elbow or tee is equal to ⅔ that of the globe valves and in the calculation of the length of pipe in order to secure resistance to air flow, these lengths must be added to the actual length of the pipe line for each globe valve, elbow and tee. It is preferable in compressed air lines to employ gate valves instead of globe valves as their resistance is considerably less.

In the care of air pipe lines it should be remembered that leaks must not occur; when pressure will not remain overnight as indicated by the pressure gage, the pipe system cannot be considered in first-class condition.

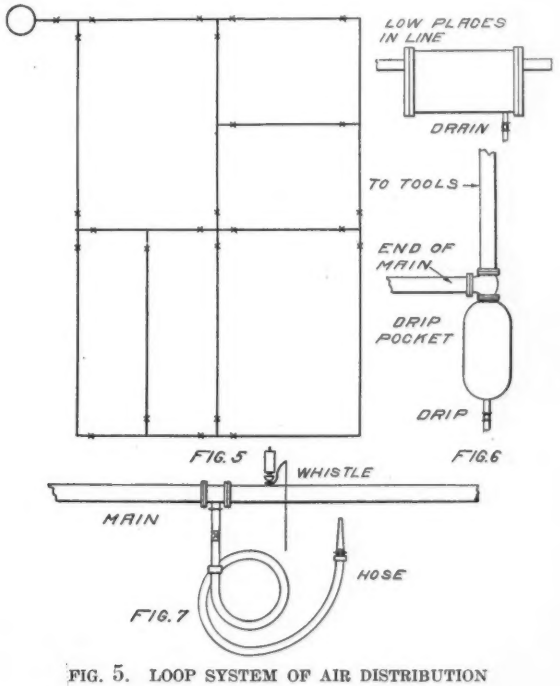


FIG. 5. LOOP SYSTEM OF AIR DISTRIBUTION

FIG. 6. METHODS OF DRAINING AIR PIPE SYSTEMS

FIG. 7. CONNECTIONS FOR HOSE AND WHISTLE

The pipes should be placed above ground, in transmission lines, where they can be cooled and properly inspected. When, however, pipes must be placed beneath the ground, the tunnel system is the one best employed.

An idea as to the amount of loss taking place in the line may be had by stopping up all outlets and counting the number of strokes of the compressor which are required to maintain the required pressure upon the pipe system. For inspecting pipes, a good plan is to paint the joints, valves, tees, etc., with soapy water and the leak will show up quickly by this method where the sound of escaping air may not be heard. Flange joints are preferable to screwed joints as leaks are more easily prevented. Care should be taken in packing a joint to cut the packing so as not to interfere with the flow of air.

Every low place in the pipe system should be provided with a secondary receiver and drain cock. The importance of keeping the air free from moisture cannot

be over emphasized as it will freeze up in the air motor and reduce its capacity if not removed.

Richards advises that the velocity of air in main pipe lines should not be more than 20 ft. per second and in branch lines the velocity should be still less for best operation.

For connecting up small motors, drills, chisels, etc., to the pipe system, a flexible air hose is employed which is similar in all respects to steam hose. It is made strong and flexible and may be either of rubber reinforced with wire or entirely of metal. Couplings of the hose should be such that they do not interfere with the flow of the air and strong enough to prevent all leaks.

In engine rooms, compressed air is used largely for blowing dust and dirt from electrical machinery. For this purpose, the main should be at least 1 in. in diameter and the branches ¾ in.; ½-in. hose with a small opening

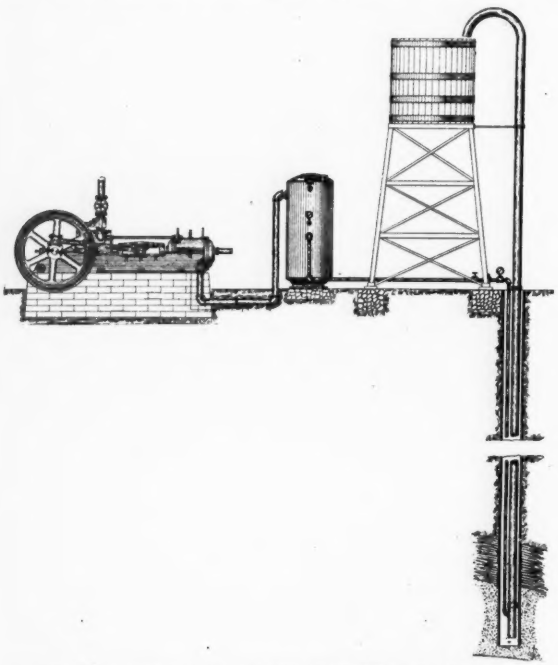

FIG. 8. TYPICAL AIR-LIFT PUMPING PLANT PIPING

nozzle provided with a valve is most convenient. Hose connections should be conveniently located and of sufficient number that all parts of the machines can be reached with a comparatively short hose. The coupling for attaching the hose to the branch outlet should be of such a design that it can be worked by hand without a wrench.

For cleaning motors driving stokers, coal conveying machinery or other machinery in the boiler room, piping and hose connections, similar to that used in the engine room, may be employed to advantage. When such work is done, the precaution should be observed to see that the line is properly drained of water, as a dose of water on electrical machinery may cause serious trouble.

In plants where compressed air is always available, air whistles for signaling are more satisfactory than electric bells or steam whistles. The whistle should have a tone that will be readily distinguished from the noise of machinery. One whistle properly located and operated from various stations about the plant by means of electric pushbuttons will serve for signaling between switchboard, engine room and boiler room or a separate whistle may be installed at each station without the electric circuit.

For operating tube cleaners, blowing flues, driving chisels, hammers, etc., compressed air is extremely convenient about power plants and their machine shops. In all such cases, the main and branch piping should be designed to care for the air it will carry. The connections from outlet pipe to the tool is usually a metallic hose, except when the motor operated is permanently located, then pipe connection is made.

Ice hoists in the freezing room of ice plants are sometimes operated by compressed air. In such cases, some means must be provided for supporting the hose connection; the usual method is a cable with trolley supports which automatically gathers up the hose and pays it out as the operator works over various parts of the tank.

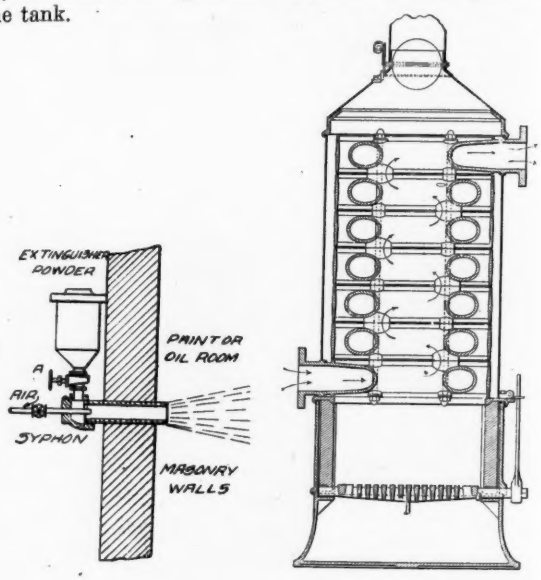


FIG. 9. AIR SPRAY FOR FIRE PROTECTION
FIG. 10. TYPICAL REHEATER SHOWING PATH OF AIR

In recent years air-lift pumping has become common in power plants where deep wells are depended upon for water supply. Its principal advantage is that all moving machinery is above ground where it can readily be inspected and repaired. The air piping system is extremely simple, air being delivered from the compressor to the receiver and then to the pump in the well as indicated in Fig. 8.

Among the special uses for compressed air is in connection with fire protection systems. In the dry-pipe sprinkler system described elsewhere in this issue, air pressure is maintained in the piping system. For such systems motor driven, belted, steam or hand operated air compressors are used according to the equipment at hand. The air piping consists simply of a pipe connecting the air compressor discharge to the sprinkler piping with a valve to prevent air from leaking out of the system through the compressor. The pressure in the system is

brought up to the desired maximum and the supply valve closed; this prevents the air compressor, which may be operated continuously for other purposes, from keeping the pressure up so high that the water valve will not open when a sprinkler gives way.

Another way in which compressed air is used for fire protection is illustrated in Fig. 9. In this case, the air acts as an ejector spraying fire extinguishing powder or liquid through the wall onto the fire.

### Reheater Piping

Compressed air transmitted long distances loses its heat of compression and, theoretically at least, considerable gain in power can be obtained by heating the air just before it is used in the tools. Reheaters are in principle similar to ordinary house furnaces; the pressure, however, is high and they must be built to withstand this and the strains due to changes in temperature. Figure 10 shows the cross section of a typical reheater which is located as near to the point where the air is used as is possible.

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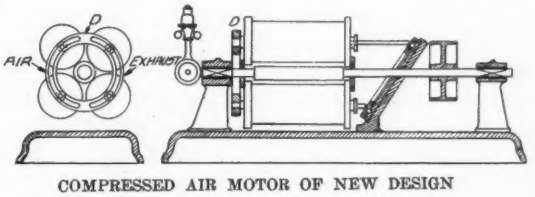
M. Schilde, of New Orleans, has patented a system for freezing raw water ice by playing a blast of cold air or other refrigerant directly against a film of water which travels over a brine plate. The freezing starts on the plate and continues progressively, the ice building up from freezing of the film, and the heat being abstracted by direct contact of the refrigerant with the water film. Claims are made for simplicity and rapidity, but no test figures are available as to performance.

# New Type Compressed Air Motor

By J. H. Blakey

A ROUMANIAN engineer, M. Pacuraro, has brought out a compressed air motor which embodies some new ideas in motor construction. As will be seen by the drawing, the cylinders are arranged concentrically around the shaft to which they are keyed. The rounded end of each piston bears on a recess in an elliptical plate, mounted on ball bearings. Plate D, at the back of the ring of cylinders, is cut through by 2 circular grooves, as shown in the end elevation, each groove occupying about 140 deg. of the circle. One groove allows the entrance of compressed air to the cylinders and the other serves as exhaust. It will be noticed that neither a flywheel nor connecting rods are required, which, in the case of the connecting rods at least, is an obvious advantage. The whole arrangement is thus very compact and simple in construction.




COMPRESSED AIR MOTOR OF NEW DESIGN

The inventor claims that with slight modifications it will work equally well with compressed air, steam, gas, or under a head of water. The drawing shows 4 cylinders, but these may be any number.

POUNDS PRESSURE LOST BY FRICTION IN 1000 FT. OF AIR PIPE

| Size Pipe | DELIVERY IN CUBIC FEET OF COMPRESSED AIR PER MINUTE AT 80 LBS. GAGE | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7.74 | 11.3 | 15.2 | 19.4 | 23.2 | 27.2 | 31.0 | 38.7 | 46.5 | 54.2 | 62.0 | 69.7 | 77.4 | 92.9 | 108.2 | 124.0 | 139.5 | 152 | 232 | 310 | 387 | 465 | 542 | 620 | 697 | 774 |
| | EQUIVALENT DELIVERY IN CUBIC FEET OF FREE AIR PER MINUTE | | | | | | | | | | | | | | | | | | | | | | | | |
| | 50 | 75 | 100 | 125 | 150 | 175 | 200 | 250 | 300 | 350 | 400 | 450 | 500 | 600 | 700 | 800 | 900 | 1000 | 1500 | 2000 | 2500 | 3000 | 3500 | 4000 | 4500 | 5000 |
| 1 " | 14.31 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1¼" | 3.96 | 8.46 | 15.31 | | | | | | | | | | | | | | | | | | | | | | | |
| 1½" | 1.53 | 3.26 | 5.92 | 9.64 | 13.79 | | | | | | | | | | | | | | | | | | | | | |
| 2 " | .33 | .71 | 1.28 | 2.09 | 2.99 | 4.09 | 5.34 | 8.32 | 12.01 | | | | | | | | | | | | | | | | | |
| 2½" | .10 | .21 | .39 | .64 | .91 | 1.25 | 1.63 | 2.54 | 3.67 | 4.99 | 6.53 | 8.25 | 10.81 | | | | | | | | | | | | | |
| 3 " | .03 | .08 | .14 | .24 | .34 | .47 | .61 | .96 | 1.38 | 1.88 | 2.45 | 3.13 | 3.83 | 5.61 | 7.46 | 9.86 | | | | | | | | | | |
| 3½" | .01 | .03 | .06 | .11 | .15 | .21 | .27 | .43 | .62 | .84 | 1.11 | 1.40 | 1.73 | 2.46 | 3.37 | 4.42 | 5.61 | 6.64 | 15.41 | | | | | | | |
| 4 " | | .01 | .03 | .05 | .07 | .10 | .13 | .21 | .30 | .41 | .54 | .69 | .85 | 1.22 | 1.66 | 2.18 | 2.77 | 3.29 | 7.62 | 13.62 | | | | | | |
| 4½" | | | .02 | .03 | .04 | .06 | .07 | .12 | .17 | .23 | .30 | .38 | .47 | .68 | .92 | 1.19 | 1.54 | 1.82 | 4.24 | 7.58 | 11.79 | | | | | |
| 5 " | | | .01 | .01 | .02 | .03 | .04 | .07 | .09 | .13 | .17 | .22 | .27 | .39 | .53 | .69 | .88 | 1.04 | 2.43 | 4.32 | 6.88 | 9.72 | 13.25 | | | |
| 6 " | | | | | .01 | .01 | .01 | .02 | .03 | .05 | .06 | .08 | .10 | .15 | .20 | .27 | .34 | .40 | .95 | 1.69 | 2.64 | 3.79 | 5.27 | 6.78 | 8.54 | 10.55 |
| 7 " | | | | | | | | .01 | .01 | .02 | .03 | .04 | .05 | .06 | .09 | .12 | .15 | .18 | .43 | .77 | 1.19 | 1.73 | 2.35 | 3.07 | 3.89 | 4.79 |
| 8 " | | | | | | | | | | .01 | .01 | .01 | .02 | .03 | .04 | .06 | .08 | .09 | .22 | .39 | .60 | .87 | 1.19 | 1.55 | 1.97 | 2.46 |
| 9 " | | | | | | | | | | | | | .01 | .02 | .02 | .03 | .04 | .05 | .12 | .21 | .33 | .48 | .65 | .85 | 1.08 | 1.33 |
| 10 " | | | | | | | | | | | | | | .01 | .01 | .02 | .02 | .03 | .06 | .12 | .19 | .28 | .37 | .49 | .66 | .77 |
| 12 " | | | | | | | | | | | | | | | | .01 | .01 | .01 | .02 | .04 | .07 | .11 | .15 | .19 | .25 | .30 |
| 14 " | | | | | | | | | | | | | | | | | | | .01 | .02 | .03 | .05 | .06 | .09 | .11 | .14 |
| 16 " | | | | | | | | | | | | | | | | | | | | .01 | .01 | .02 | .03 | .04 | .05 | .07 |

| Size Pipe | DELIVERY IN CUBIC FEET OF COMPRESSED AIR PER MINUTE AT 125 LBS. GAGE | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5.26 | 7.89 | 10.51 | 13.15 | 15.79 | 18.41 | 21.05 | 26.30 | 31.58 | 36.81 | 42.10 | 47.30 | 52.60 | 63.20 | 73.70 | 84.20 | 94.70 | 105.1 | 157.9 | 210.5 | 263.0 | 315.8 | 368.1 | 422.0 | 473.0 | 526.0 |
| | EQUIVALENT DELIVERY IN CUBIC FEET OF FREE AIR PER MINUTE | | | | | | | | | | | | | | | | | | | | | | | | |
| | 50 | 75 | 100 | 125 | 150 | 175 | 200 | 250 | 300 | 350 | 400 | 450 | 500 | 600 | 700 | 800 | 900 | 1000 | 1500 | 2000 | 2500 | 3000 | 3500 | 4000 | 4500 | 5000 |
| 1 " | 9.88 | 22.20 | 39.50 | | | | | | | | | | | | | | | | | | | | | | | |
| 1¼" | 2.70 | 6.07 | 10.82 | 16.88 | 24.33 | 33.05 | | | | | | | | | | | | | | | | | | | | |
| 1½" | 1.05 | 2.37 | 4.22 | 6.58 | 9.47 | 12.90 | 16.84 | 26.30 | 37.90 | | | | | | | | | | | | | | | | | |
| 2 " | .23 | .51 | .91 | 1.42 | 2.04 | 2.78 | 3.63 | 5.68 | 8.18 | 11.08 | 14.51 | 18.38 | 22.68 | | | | | | | | | | | | | |
| 2½" | .07 | .16 | .28 | .43 | .63 | .85 | 1.11 | 1.73 | 2.51 | 3.39 | 4.44 | 5.61 | 6.95 | 10.00 | 13.60 | 17.80 | | | | | | | | | | |
| 3 " | .03 | .06 | .10 | .16 | .23 | .32 | .42 | .65 | .94 | 1.27 | 1.67 | 2.11 | 2.61 | 3.76 | 5.11 | 6.68 | 8.45 | 10.52 | 23.48 | | | | | | | |
| 3½" | .01 | .03 | .05 | .07 | .11 | .14 | .19 | .29 | .42 | .58 | .75 | .95 | 1.18 | 1.69 | 2.31 | 3.01 | 3.81 | 4.71 | 10.59 | 18.81 | 29.40 | | | | | |
| 4 " | | .01 | .02 | .04 | .05 | .07 | .09 | .15 | .21 | .28 | .37 | .47 | .58 | .84 | 1.14 | 1.49 | 1.88 | 2.32 | 5.23 | 9.30 | 14.52 | 20.90 | 28.51 | | | |
| 4½" | | | .01 | .02 | .03 | .04 | .05 | .08 | .12 | .16 | .21 | .26 | .32 | .46 | .63 | .83 | 1.04 | 1.29 | 2.90 | 5.15 | 8.05 | 11.59 | 15.78 | 20.61 | 26.10 | 32.20 |
| 5 " | | | | .01 | .02 | .02 | .03 | .05 | .07 | .09 | .12 | .15 | .18 | .27 | .36 | .47 | .60 | .74 | 1.65 | 2.94 | 4.60 | 6.63 | 9.01 | 11.80 | 14.90 | 18.45 |
| 6 " | | | | | .01 | .01 | .01 | .02 | .03 | .04 | .05 | .06 | .07 | .10 | .14 | .18 | .23 | .29 | .64 | 1.15 | 1.80 | 2.59 | 3.53 | 4.61 | 5.83 | 7.20 |
| 7 " | | | | | | | | .01 | .01 | .02 | .02 | .03 | .03 | .05 | .06 | .08 | .11 | .13 | .29 | .52 | .82 | 1.18 | 1.61 | 2 19 | 2.65 | 3.27 |
| 8 " | | | | | | | | | | .01 | .01 | .01 | .02 | .02 | .03 | .04 | .05 | .07 | .15 | .26 | .41 | .60 | .81 | 1.06 | 1.34 | 1.65 |
| 9 " | | | | | | | | | | | | .01 | .01 | .01 | .02 | .02 | .03 | .04 | .08 | .15 | .23 | .33 | .45 | .58 | .73 | .90 |
| 10 " | | | | | | | | | | | | | | .01 | .01 | .01 | .02 | .02 | .05 | .08 | .13 | .19 | .26 | .34 | .43 | .53 |
| 12 " | | | | | | | | | | | | | | | | .01 | .01 | .01 | .02 | .03 | .05 | .07 | .10 | .13 | .17 | .21 |
| 14 " | | | | | | | | | | | | | | | | | | | .01 | .02 | .02 | .03 | .04 | .06 | .08 | .10 |
| 16 " | | | | | | | | | | | | | | | | | | | | .01 | .01 | .02 | .02 | .03 | .04 | .05 |

For longer or shorter pipes the friction loss is proportional to the length, *i.e.*, for 500 feet ½ of the above: for 4,000 feet four times the above, etc.

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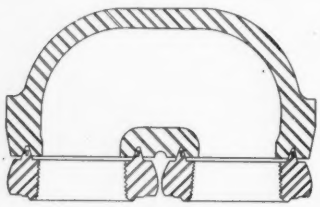
# Piping for Refrigerating Systems

FITTINGS FOR AMMONIA LINES

IN PIPE LINES which handle ammonia, no copper or any alloy containing copper, such as brass, can be used, as the ammonia will affect the copper. Neither is cast-iron suitable, because under the action of ammonia it becomes porous. All piping, fittings and valve parts must, therefore, be of wrought-iron or steel.

As it is dangerous to have the ammonia fumes escaping, it is necessary that the joints shall be securely made, and special, heavy fittings are used at all points. Where screwed joints are used, the fittings are heated, then screwed and usually sweated on with solder, and in most instances, a recess is made at the end of the fitting, which is either filled with solder or packed with some sort of soft packing forced into the recess by a gland. The faces of the fittings are tongued and grooved and packed by means of gaskets, soft lead being commonly employed.



The double-return connections for double-pipe condensers and coolers have a double through stuffing box for the larger pipe, with a recessed joint return end for the smaller pipe, the fittings being made of semi-steel with through bolts.

For expansion coils, lengths of pipe are welded up and bent to shape, or return bends with flanged ends are used, these return bends being of the special type mentioned. A series of the different types of joints is shown in the accompanying illustrations. The smallest pipe practical should be used, and for the high-pressure side of the system, extra heavy pipe is usually required, on account of the high pressures carried and the importance of getting the system tight at all points. Piping and fittings should be tested to 500 lb. hydraulic pressure, and the completed system to 300 lb. air pressure, the joints being coated with soapy water to detect any leakage.

Valves for the ammonia system have special, long stuffing boxes for the stem, and for expansion coils are usually either in the form of a spring cock with capped ends having a V-shaped opening, the point opening first for fine adjustment, or of the needle valve type with a solid point fitting into a tapered seat.

In direct expansion coils, a single coil can be worked up to 5000 ft. in length of 1½-in. pipe, and will require ½-in. liquid feed line, but ordinarily it is better to divide the coils into 300 to 1500 ft. each, having an inlet and outlet valve at the end of each section so that the refrigeration can be more closely regulated. Expansion joints and bends must be provided the same as for steam lines, but must be of heavier construction and with special ammonia type fittings at all points.

## COMPRESSOR PIPING

PIPING FOR the steam end of the compressor is the same as for any other steam engine and needs no special comment. For the ammonia end, the main piping is the suction line, which comes from the expansion coils through a separator to remove the scale, and the discharge, or head pressure line, which is carried either to a pressure tank or oil separator for removing the oil, or in larger plants through a forecooler, which tends to condense out the oil, and then to the pressure tank where the oil is deposited.

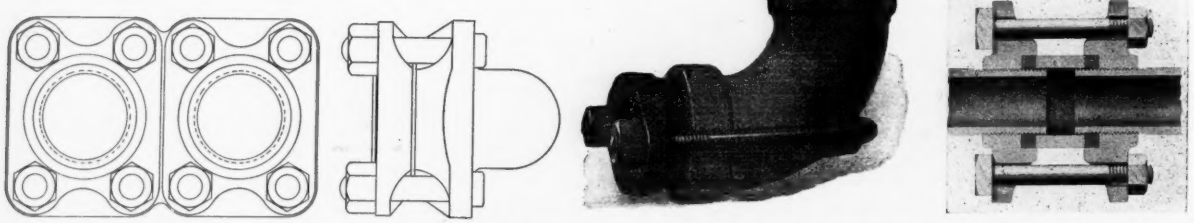


FIG. 1. TYPES OF AMMONIA FITTINGS: EDWARD SPRING JOINT; YORK BRINE TANK ELBOW BOYLE UNION

From the bottom of the oil separator or pressure tank, the oil is carried back to the compressor cylinder, if oil injection is used, and to the lantern stuffing box on the piston rod gland. Provision is made by means of a gage glass for keeping track of the amount of oil in the pressure tank or separator, and for pumping in more oil as may be needed. From the piston rod lantern, a pressure relief line is carried to the pressure tank or oil separator, to permit any ammonia which may escape past the packing to return to the high-pressure side of the system. Since the oiling system carries the full head pressure, all valves on this system must be of the

ammonia type, and as the piping is small, bends are usually made with pipe rather than fittings.

A liquid injection line is also carried from the main liquid tank to the suction line near the compressor, so that liquid ammonia may be injected to cool the incoming gas when necessary. Cross-connections are made between the suction and discharge lines to permit pumping out of different parts of the system and storing the ammonia in any other part during repairs, and also to permit pumping out the compressor itself when repairs are necessary.

TABLE I. SIZE OF AMMONIA MAINS

| Refrig. Capacity Tons | Diam. Liquid Line, In. | Diam. Suction Line, In. |
|---|---|---|
| 5 | 1/2 | 1-1/4 |
| 10 | " | 1-1/2 |
| 25 | " | 2 |
| 40 | 3/4 | 2-1/2 |
| 75 | 1 | 3 |
| 120 | 1-1/4 | 4 |

Length 100 ft. Gas velocity 80 ft. per sec.
For length over 100 ft. or velocity over 80 ft. use next larger size pipe.

In compressors having a water-cooled jacket, provision must also be made for a water supply line to the jacket with capacity for 1/5 gal. per minute per ton capacity, and an overflow which will usually be taken to the sewer.

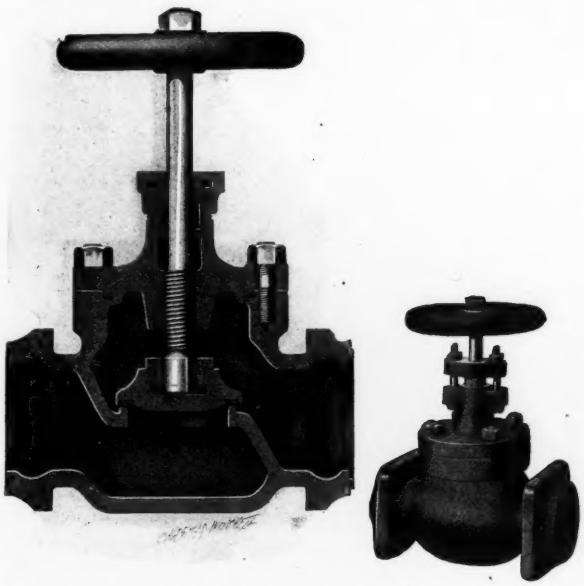


FIG. 2. AMMONIA VALVES; YORK AND ARCTIC

### Ammonia Condenser Piping

The condenser may be of atmospheric, double-pipe or submerged type, according to requirements of the plant, the atmospheric being the most common. For this type, cooling water is carried to a distributing system, flows over the condenser pipes at the rate of 1 gal. per min. per ton capacity for temperature of 65 deg., and is collected in a pan below, from which it is drained off for further use. In the double-pipe system the water is usually admitted at the bottom of the condenser and flows upward in a closed, continuous 1¼-in. pipe which is inside the 2-in. ammonia pipes. It is taken off at the top and carried to the steam condenser.

Ammonia is brought to the condenser from the oil separator or pressure tank through a check valve, a ½-in. line being connected for the injection of liquid ammonia in front of this check valve to prevent slamming of the valve if the gas is greatly superheated. In the atmospheric type, the ammonia is preferably admitted to the bottom coils of the condenser, and passes upward. Connections are made at various points to draw off such liquid ammonia as is condensed and carry it to a header, each section of the condenser having its own header so that any section may be isolated and pumped out without shutting down the rest of the plant. In the double-pipe condenser, ammonia is admitted at the top and flows downward.

FIG. 3. YORK EXPANSION VALVE

For water at 60 deg., 22 sq. ft. of pipe surface should be provided per ton refrigeration; for water at 75 deg., 28 sq. ft., the liquid ammonia being drawn from the lower end of the ammonia coil to a common liquid header. The surface needed is about 14.5 sq. ft. per ton capacity. Each section of the condenser has a valve at the inlet and outlet, and connection is provided from each section of the condenser to the suction side of the compressor, so that the section may be pumped free of ammonia for repair. The condenser should be set with 1 in. fall in 10 ft. toward the liquid header, so that it will drain at all times. In order to clean sediment from the water pipes of a double pipe condenser, it is well to have compressed air connected to each coil so that it may be blown out separately into a drain as shown in Fig. 6.

For the submerged condenser, which has an ammonia coil of 30 sq. ft. surface per ton refrigeration made up of 1¼- or 1½-in. pipe, submerged in a water tank, the ammonia gas is admitted at the top of the coil, and the liquid withdrawn at the bottom. Deep tanks are best,

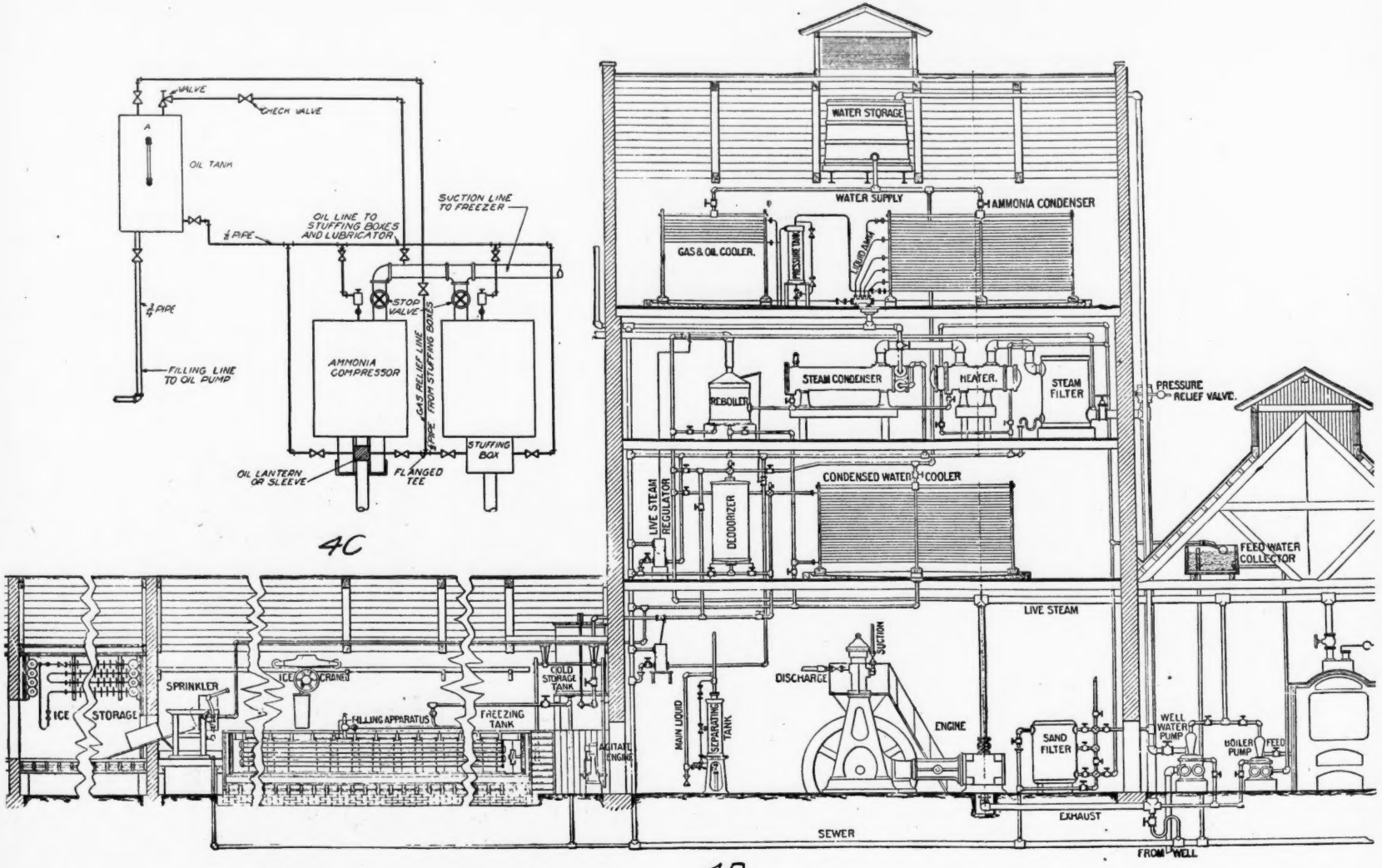



FIG. 4. GENERAL ARRANGEMENT OF AMMONIA COMPRESSION ICE PLANT; 4A, CONNECTIONS OF STEAM AND WATER SYSTEM FOR DISTILLED WATER PLANT; 4C, CONNECTIONS FOR COMPRESSOR OILING SYSTEM

the water being supplied through a spreader nozzle at the bottom and overflowing from the top, the supply being 2½ to 3 gal. per min. per ton refrigerating capacity with inlet temperature of 60 deg. F.

From the liquid ammonia header the liquid is taken to an oil separating or receiver tank, having ½ gal.

TABLE II. EXPANSION COIL SURFACE

| Location | Sq. Ft. Pipe Surface |
|---|---|
| Freezing Tank..... | 100 per ton ice capacity |
| Brine Tank..... | 50 " " refrigerating capacity |
| Brine Cooler..... | 10 " " " " |
| Freezing Chamber..... | 350 " 1000 cu. ft. |
| Storage Room..... | 35 " " " " |

capacity per ton of refrigerating capacity, any scale being discharged by a goose-neck outlet to prevent backing up of gas, and deposited in a scale pocket.

From the receiver the main liquid line is taken to the expansion coils. Both pressure tank and separating tank have gage glasses to show the height of the liquid, the valves at the ends of these glasses being of special self-closing type to prevent escape of ammonia in case a glass breaks.

At the top of the condenser a purge cock is usually provided to draw off noncondensible gases, although modern practice is tending toward the purging of the system continuously by means of a small double-pipe purging condenser connected to the liquid receiver and discharging into a water tank. An equalizer connection is carried from the top of the separator tank to the top of the condenser, to carry off ammonia gas which may form in the separator and return it to the condenser, and to bring noncondensible gases to the purging condenser.

The main liquid line from the separating tank is usually run from the bottom with a controlling valve, beyond which a branch is taken for charging ammonia into the system. Small lines are also run from the liquid injection to the compressor, and for emergency uses.

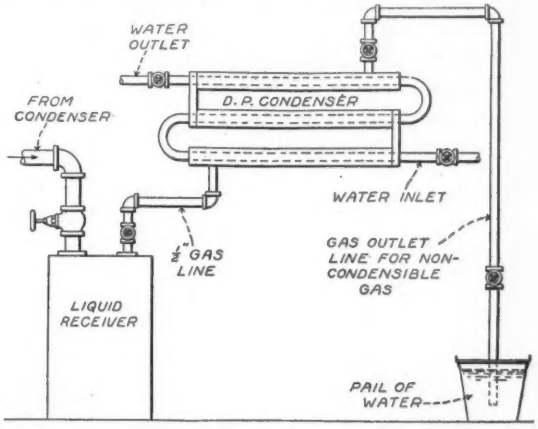



FIG. 4D. ARRANGEMENT OF PURGING CONDENSER

## Expansion System

Expansion coils are used either for direct cooling of the rooms or for cooling the brine in the brine tank and ice-freezing tank. For the direct expansion cooling, in some systems the coils are covered with disks to increase the surface, although the plain coil is more common. As cold air falls, the expansion coils in the direct system should be placed near the ceiling, and if on the sides of the room should be hung on offset brackets 3 in. from the wall, so that air can circulate behind them. They are often suspended from the ceiling on horizontal or vertical racks.

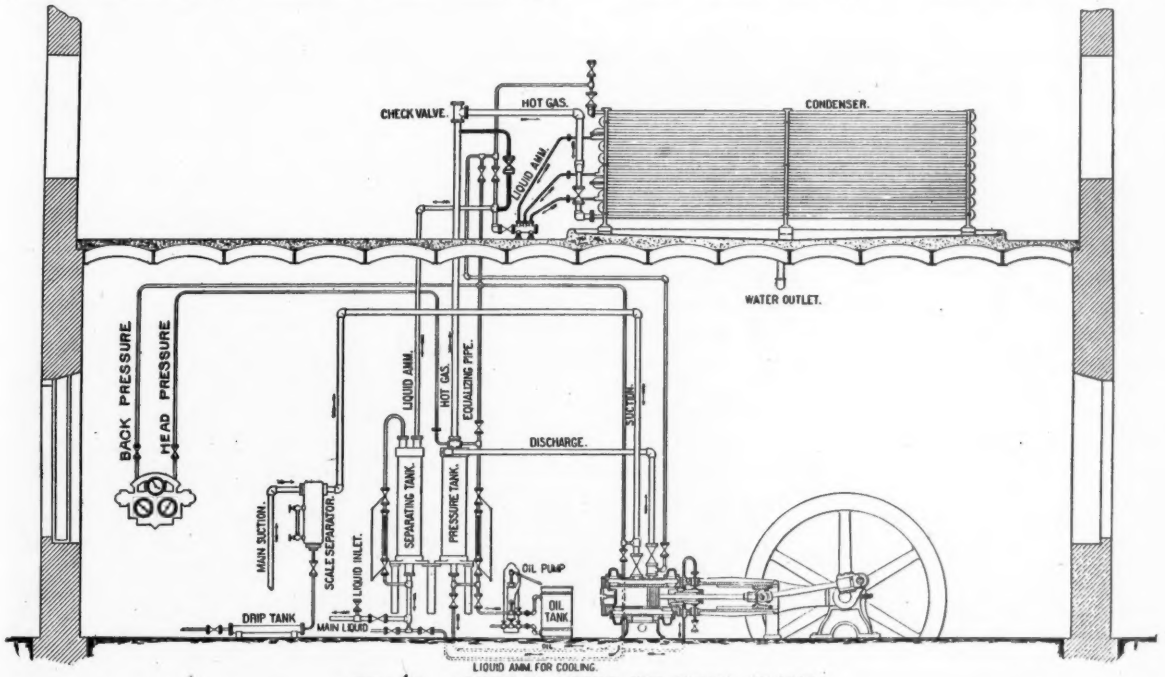



FIG. 4B. AMMONIA PIPING FOR SMALL PLANT

Each section of the expansion coils must have its own inlet and outlet valves, and direct expansion coils should be so connected that each one may be pumped out separately when repairs are necessary. For brine tank coils this is not essential, since the whole tank must be shut down and drained before work can be done on a coil.

In ice tanks, the expansion coils are so spaced that a row of cans will set between 2 coils or for plate systems the coils are enclosed in plates spaced 15 to 18 in. apart. The surface needed can be found by using Table II.

To bring all connections at the top of the tank, it is well to admit the liquid at the top of half the coils and connect the bottom end of all coils to an equalizing manifold. The other half of the coils are connected at the top through outlet valves to the suction header from which the main suction line is taken. If this method is not used, ammonia should be admitted at the bottom of each coil and drawn from the top for a dry gas system, or admitted at the top and drawn from the bottom for a wet gas or flooded system.

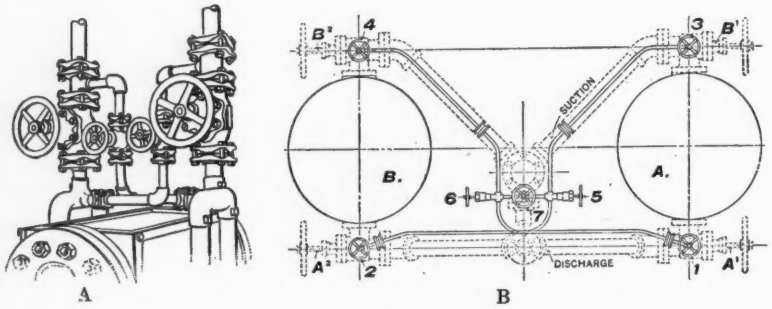



FIG. 5. CROSS-CONNECTIONS AT COMPRESSOR BETWEEN SUCTION AND DISCHARGE; A, FOR SINGLE CYLINDER HORIZONTAL COMPRESSOR; B, FOR DOUBLE VERTICAL COMPRESSOR

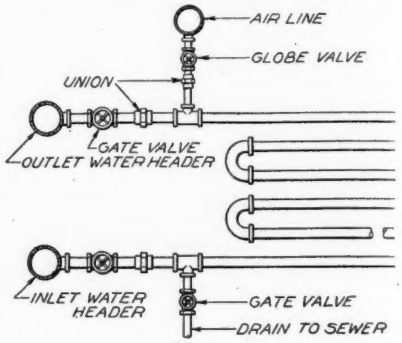



FIG. 6. CONNECTIONS FOR AIR BLOWING FOR DOUBLE PIPE CONDENSER

## Water System

In the distilled water ice plant, exhaust steam from the engine is condensed for making ice, and, if necessary, live steam is admitted to the condenser to increase the amount of distilled water available, or water is evaporated by the heat from the exhaust steam. The exhaust steam passes, first, to a steam purifier, which removes the oil, then to the heater where it heats boiler feed, or to the evaporator for distilled water, next to the steam condenser, where it is condensed, and from which it flows to the reboiler where it is heated by a steam coil to the boiling point to drive off air and other gases. From the re-boiler the water passes to the water cooler, which is of the same construction as an atmospheric ammonia condenser, whence it is carried to the sweet water storage tank in the freezing room. From this tank it is drawn through a hose connection to the can filler as needed.

Live steam connection is provided to the reboiler, also to water cooler and filter for blowing out. The condensation in the reboiler coil may be discharged into the water and passed to the water cooler, or collected from the coil and sent to the hot well for boiler feed.

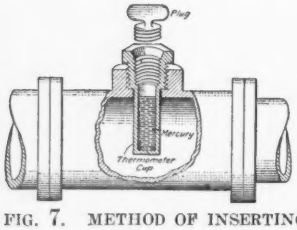



FIG. 7. METHOD OF INSERTING THERMOMETER CUP IN AMMONIA OR BRINE LINE

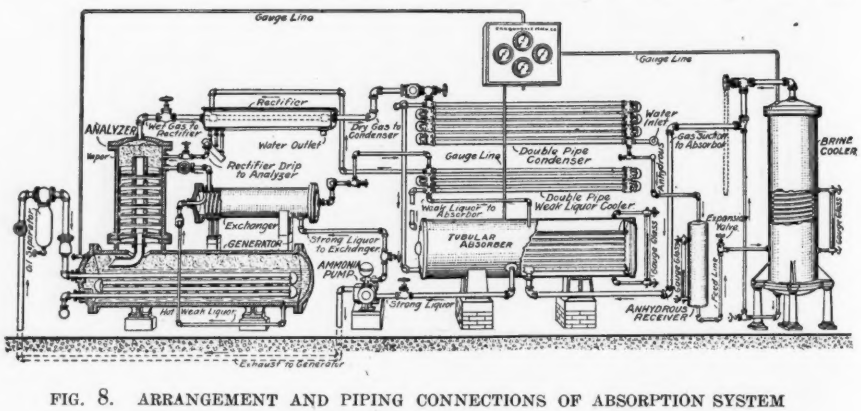



FIG. 8. ARRANGEMENT AND PIPING CONNECTIONS OF ABSORPTION SYSTEM

No galvanized iron pipe should be used in a direct expansion system.

In all ammonia lines, it is desirable to know the temperatures being maintained, but this can be readily done by means of gages since the tables of properties of ammonia gas give the relation. Such gages should be connected to register suction and head pressures. For the temperature of rooms, brine coils and tanks, thermometers must be used, and many operators prefer thermometers even on ammonia lines. These should be placed in cups, inserted in the lines as shown in Fig. 7, the cup being of iron or steel.

It is also desirable to have an outlet for live steam in compressor and freezing rooms to which a steam hose may be connected for blowing out coils and tanks when overhauling the plant.

Cooling water is passed, first, over the forecooler and ammonia condenser, then through the steam condenser, and such part as is needed is then taken to the hot well, passing, if dirty, through a filter on the way. Water for cooling the reboiled water is taken direct from the storage tank or water system, and after passing over the cooler, part of it is taken to the ice freezing room to be used in sprinkling the cans to thaw the cakes of ice loose when pulling; such of the balance as is needed is taken to the hot well, and the remainder discharged to the sewer or pumped to the cooling tower if one is used. Provision is also made for passing a certain part of the boiler feed through a feed water heater, which is heated by the exhaust steam from the engine before it goes to the steam condenser.

In order to keep the reboiler always filled, a float in the reboiler actuates a valve in the outlet pipe to the water cooler. Impurities in the condensed steam are carried off by the skimmer in the reboiler, and a float tank in the skimmer outlet opens the admission valve for live steam to the steam condenser, when the level in the reboiler falls and closing it off when the reboiler is full. There should be a shutoff valve between reboiler and outlet float valve so that the latter may be repaired without emptying the reboiler.

Generally it is found desirable to pass the cooled condensation through a filter before sending it to the sweet water storage tank, and in some instances an expansion cooling coil, taking gas from the ice tank coils is located in this storage tank to cool the water down to 32 deg. before it is used to fill the cans, or the tank.

Bypass provision is made so that the filter may be shut down for cleaning and water sent from the cooler direct to the storage tank, also for sending direct to the can filler from the filter while the storage tank is being cleaned or repaired.

For a raw water ice plant, the water is first filtered, then sent direct to the cans, and agitation in the can by means of compressed air is used to drive out foreign matter and gases. The air line should have a capacity of 6.5 cu. ft. of air per minute for each 300-lb. can and the air pressure should be about 3 lb. in the header for 3/16-in. openings, or 1 lb. for ¼-in. openings in the supply nozzle to the cans, with brine at 14 deg. F. For lower temperature increase the air supply, also for water containing more than 4 grains of solids to the gallon. It is well to increase the air pressure slightly as the freezing nears completion, on account of the concentration of solids in the water at the center of the can.

In some plants, the water is passed first over the atmospheric condenser, then used in the steam condenser, and finally sent to a reboiler, so much of it as is needed being used with the condensed steam in place of condensing live steam, and the remainder being sent to the boiler feed.

### Absorption System

In the absorption system, the generator and absorber take the place of the compressor, the arrangement being as shown in Fig. 8. For the rest of the system, the arrangement and piping connections are the same as for the compression system and need no further mention.

The absorber takes gas from the expansion coils, and it is taken up by the weak liquor, which is delivered to the top of the absorber, usually in spray form. The gas enters the bottom of the absorber and passes up through the weak liquid, which thereby becomes charged with ammonia, the strong liquid being found near the top, so that the pump takes its suction from well up on the side of the absorber shell. The strong liquor is then pumped through the exchanger, which is shown of the shell type, the strong liquor being outside the coils and the weak liquor from the generator passing through the coils on its way to the weak liquor cooler.

From the exchanger, the strong liquor passes upward and is delivered to the analyzer, which is much the same as an open feed-water heater. The liquor passes down over a series of pans, around which the gas from the generator is rising, the falling liquor tending to take moisture out of the rising gas, and the gas absorbing such ammonia as escapes from the strong liquor in the analyzer. At the bottom of the analyzer, the strong liquor passes into the generator, where it is heated by steam coils, the ammonia gas being thus driven off and passing upward to the rectifier, where it is sent through a series of coils which are covered with water, the water vapor and weak liquor being condensed out and dripped back to the analyzer. From the rectifier, the ammonia gas passes over to the condenser, which may be of atmospheric or double pipe type, as in the compression system.

Weak liquor having parted with its gas is forced by the pressure in the generator up through the exchanger and over to the weak liquor cooler, through which it flows back to the absorber. Condenser, weak liquor cooler and absorber are cooled by water spray or flowing through coils to keep the temperatures on this side of the system as low as possible. The pressure inside the absorber is kept at about 15 lb., and in the generator at about 110 to 180 lb., depending on the temperature of cooling water available.

Throughout the ammonia system, the same style of valves, fittings and piping is used as for the compression system, and the same provision is made in the condenser or the liquid receiver for purging ammonia of foul gases. Since there is no opportunity for oil to mix with the ammonia, no oil separator or pressure tank is necessary, such scale as may come from the pipes of the system being taken out in the liquid receiver.

Water which has been used for cooling the ammonia and liquor is discharged to the hot well and used for boiler feed, and the exhaust steam from the ammonia pump is used, together with such live steam as may be necessary, in heating the generator. Condensation from the generator may be used for making distilled water ice, or in the case of a raw water ice plant, may be carried to the hot well for boiler feed.

As the liquor coming from the absorber is at comparatively high temperature, the ammonia pump must be set with its inlet below the absorber so the liquor will come to the pump under a head, to avoid vapor binding.

Pressure gages are provided, connected to the absorber and the generator, to keep track of suction

and head pressures, also generally a gage is provided on the steam line leading to the generator and on the expansion side of the ammonia system.

Ammonia from the liquid receiver may be used either in direct expansion coils for refrigeration and icemaking, or, as indicated in Fig. 8, may be sent through a brine cooler, where the brine system of refrigeration is in use. Gage glasses are provided on the absorber, generator and liquid receiver to show the height of liquid in each, and these should be provided with self-closing cocks to prevent escape of ammonia in case the glasses break.

### Brine System

Where refrigeration alone is wanted, it is generally more economical to use the direct expansion of ammonia in the coils, but if rooms are located at a considerable distance from the compressor plant, the use of brine for refrigeration, even though the first cost of installation is greater, may be preferable. In this system the expansion of ammonia is used to cool a brine made either with sodium chloride or calcium chloride, the brine being usually circulated in an open tank similar to an ice-freezing tank. A circulating pump forces the brine through the refrigerating coils and back to the tank, as indicated in Fig. 9.

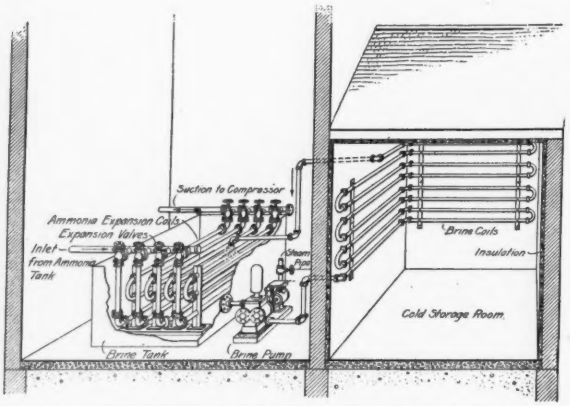



FIG. 9. CONNECTIONS FOR BRINE COOLING TANK AND REFRIGERATING COILS

As between sodium chloride and calcium chloride, the former has its low limit of temperature at about 0 deg. F., since if the temperature be carried below this, the brine will be likely to freeze. It also has a disadvantage of corroding piping, and the use of galvanized pipe is desirable where the sodium chloride brine is employed, also the circulating pump must be brass fitted throughout.

Siebel states that the sodium chloride brine may be made noncorrosive by the addition of a slight amount of soda, but the proportion is not stated, and the use of calcium chloride is becoming more common.

Calcium chloride has its low limit at —17 deg. F., and can, therefore, be used for much lower temperatures than the sodium chloride. Also, it does not corrode iron or steel, so that black piping can be used and an iron fitted pump, but it cannot be handled in wood tanks, since it will absorb the moisture from the wood and soon cause leakage.

For the brine system, a mixing tank must be provided having a false bottom on which the salt may be placed. The water is admitted below this bottom through 1¼-in. pipe and overflows at a slight distance from the top of the tank through 1½-in. pipe, the brine thus formed being carried to the brine tank. A strainer should be placed between the brine tank and the pump, and the mixing tank should be provided with strainer and with a skimmer to remove foreign matter.

It is necessary to maintain circulation in an open brine tank by means of taking the brine pump supply from the bottom of one end and discharging into the tank at the top of the other end. In the case of an ice tank, the brine must be circulated usually by means of a propeller, which for 10 tons or less capacity is 12 in. diameter, and over 10 tons, 18 in. The brine tank should have a capacity of 60 cu. ft. for each one ton of refrigeration.

In some plants the double-pipe type of brine cooler is used, which is practically the same as a double pipe ammonia condenser, the brine being circulated in the inner pipe and the ammonia passing between the inner and outer pipe. Ammonia is admitted at the bottom and ammonia gas discharged from the top, while the brine enters at the top and is pumped out at the bottom.

This cooler has the advantage of quicker action than the tank form, but is more expensive and difficult to keep clean. Sometimes the double pipe cooler is placed inside a tank in order to take advantage of the cooling effect of the outside of the ammonia piping, and in this case the brine is pumped from the tank through the brine coils, then out through the refrigerating coils, and on return is discharged into the tank.

For the brine lines, except in the tank or cooler, ordinary piping and fittings are used, but the ammonia type of fittings should be used in the coolers and in the tank coils. The brine lines should have a size such that the velocity of the brine will be not over 60 ft. per minute, a common allowance being one square inch of cross-section area per one ton refrigeration capacity, and a pump provided to circulate 4 gal. per minute per ton refrigeration.

Piping for refrigerating coils is usually made 1¼ in., from 300 to 600 ft. of pipe being installed in each coil; 800 ft. is the maximum, and the regulation should be by the outlet valve to avoid air binding in the coil.

Amount of surface required is usually given as 120 to 150 ft. of 1¼-in. pipe per ton of refrigeration capacity in the brine tank; 500 sq. ft. of pipe surface per 1000 cu. ft. for freezing chambers; 50 sq. ft. per 1000 cu. ft. for storage rooms, and 20 sq. ft. per 1000 cu. ft. for bunkers. The amount of surface required is from 1½ to 2 times that required for direct expansion coils.

In some plants a shell type of brine cooler has been used, the construction being indicated at the right in Fig. 8. In this the brine is sent through coils and the ammonia gas is admitted to the shell. A danger in this type as well as the double pipe type is, that if circulation of brine is stopped for any reason, there is likelihood of the brine freezing in the coils and bursting the pipe, unless the density of the brine is kept such that its freezing point is below the ammonia temperature, due

to the pressure in the cooler. This is undesirable, since the denser the brine the less is its capacity for absorbing heat in the refrigerating coils.

As the pressure in the brine system is usually greater than the ammonia back pressure, any leakage in the brine coils will result in the passing of brine into the ammonia. For this reason, a test cock should be provided at the bottom of the cooler, from which ammonia can be drawn off and tested for brine, which would be indicated by a muddy appearance of the ammonia.

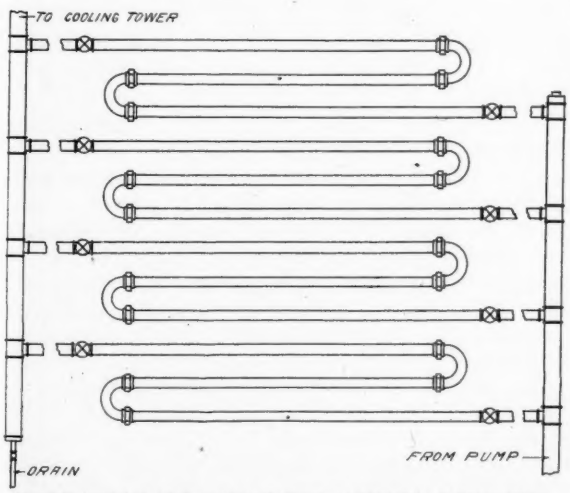
All brine pipes, except where refrigerating effect is desired, should be covered with insulation to prevent frosting, and the brine end to the circulating pump should also be covered.

As the refrigerating coils will become coated with frost, connection should also be made so that warm brine may be pumped through to thaw off this frost coating, the arrangement preferably being such that each refrigerating section may be defrosted separately without interfering with the action of the other sections in the room. A temperature of 75 deg. in the warm brine will be sufficient to defrost the coils rapidly.

# Piping for Double-Pipe Ammonia Condenser

By A. G. Solomon

WHERE water is not plentiful and has to be used over and over for the ammonia condenser, any little change in pipe work or handling which will benefit, should be resorted to. Double-pipe ammonia condensers are the most common type in small installations. As a general rule, one stand is used for a 10-ton plant and 2 for 20-ton. The counter current effect is what gives this type its advantage. Sediment will collect in the inner tubes where the water is at all dirty, and




WATER PIPING FOR DOUBLE-PIPE AMMONIA CONDENSER

if the tubes have to be scraped, it will necessitate the shutting down of the compressor while the work is being done; that is, this is the usual way where the common form of piping is used (the water admitted at the bottom of the stand and the outlet at the top).

Also, all the water is greatly heated in its passage through the entire condenser.

To overcome the shutting down of the plant while the tubes are being cleaned and also to keep the water cool as possible, the following description and sketch will prove of value. Admit the condensing water in 3, 4 or even more places and have separate outlets for each.

The illustration shows a double-pipe condenser, 12 pipes high, with 4 inlets and 4 outlets for the water.

The ammonia enters the top of the stand in the usual way, and flows downward while condensing. This hot gas will heat the water flowing through the 3 top inner tubes. This hot water then passes on to the cooling tower, where it mixes with the cooler water which comes from the other 3 outlets. Each 3 pipes of the stand has its separate water supply; the condensation of the ammonia gas is rapid and complete and the cooling tower has not near so much work to do as if all the water passed all the way from bottom to top of the stand. A greater amount of water can be used and consequently the heat exchange is greater.

When it comes to scraping the inner tubes, the compressor can be kept going. The water can be shut off any 3 pipes, the return bends removed and the scraper used while the condensing water is circulating through the other sections. Valves, of course, are provided for each inlet and outlet, and these can be regulated according to the conditions of the load or weather. The expense of installing this water arrangement is very little and any plant will gain by its use.

The illustration shows water connections for double-pipe ammonia condenser. The inlet and outlet headers must not be placed in direct line with condenser so as to interfere with removal of tubes or use of tube scraper.

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Because of the discussion and activity in regard to the working of the Adamson railroad law, the report recently issued by the Chamber of Commerce of the United States giving the history of its endeavors to prevent a strike yet preserve the use of arbitration is of especial interest. This report shows that the National Chamber advocated consistently at all times thorough investigation of wages paid, and hours of service of each class of railroad employes, and to that end endeavored to secure a hearing on the Newlands resolution for such investigation; also the course taken by Senator Newlands and the Brotherhood officials in the matter.

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Experiments by W. M. Thornton described before the British Association show that for a mixture of methane gas and air in the proportion of 9.5 per cent gas, the ease of ignition with induction coil spark increased with pressure of the mixture from 7 lb. up to 30 lb. and above that pressure up to 80 lb. the ignition became more difficult with increasing pressure, requiring larger currents. The change was not continuous but in a step by step progression.

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U. S. Civil Service Commission announces an examination for mechanical draftsman, on Jan. 17 and 18, to fill a vacancy at $1000 a yr., in the Patent Office, Department of the Interior, Washington, D. C. Age, 18 yr. or over on the date of the examination. Apply for Form 304.

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CONTENTS


Piping Materials ..... 2
Types of Piping ..... 5
Pipe Joints ..... 9
Pipe Branches and Turns ..... 15
Expansion in Piping ..... 18
Pipe Covering ..... 25
Supporting and Installation ..... 27
Water Piping ..... 33
Feed Lines ..... 36
Blowoff Piping ..... 39
House Service Piping ..... 40
Fire Service ..... 44
Condensers ..... 46
Water Treating Systems ..... 48
Hot Water Heating ..... 50
Special Services ..... 53
Steam Piping ..... 54
Auxiliary Steam Piping ..... 61
Reducing Systems ..... 64
Safety Valves ..... 66
Steam for Special Services ..... 67
Exhaust Lines ..... 70
Oil Piping ..... 74
Fuel Oil Systems ..... 78
Compressed Air Piping ..... 81
Ammonia Piping ..... 86
Piping for Double-Pipe Ammonia Condenser. By A. G. Solomon ..... 93
Editorial: An Acknowledgment. Education Condemned by Law. Standard Boilers ..... 94
Solutions to Two Operating Difficulties. By M. A. Saller. 96
Convenient Pipe Gage. By B. Francis Dashiell ..... 97
Introducing Compound into Heater. By W. A. Lailer .. 97
Relieving Strain on Blowoff Pipe. By Charles Kroeschell 98
News Notes ..... 98
Catalog Notes ..... 99
Trade Notes ..... 100


## An Acknowledgment

In this issue is to be found a compilation of the best modern piping practice for power plants, gathered from all available sources. No claim is made for originality except of some diagrams and tables, and in many places direct mention is made of the sources of information. This has not been possible at all points on account of the close interweaving or averaging of data, and we would here express our debt to standard authors and current periodical literature for information, ideas and illustrations. Among the authors consulted were Kent, Collins, Morris, Gebhardt, Hubbard, Schmidt, Siebel, Gueth, Cosgrove, Booth, Koester, Richards, Weightman, Hiscox, Marks, Johnson, Haynes, National Board of Fire Underwriters, and the International Correspondence Schools, to all of whom we are indebted, and to whom we express our thanks for their work that has made it possible to bring together this complete resume. It has not been possible to present every detail of every kind of system in such limited space, but all essential principles have been covered, and we present what we feel certain is the most comprehensive treatment of the subject of Piping for the Power Plant that has appeared in print.

## Education Condemned by Law

Wise and far-seeing legislators of the last generation, realizing that advancement of our nation as a whole and of its citizens depended largely on wide-spread intelligence and dissemination of reliable information, took the ground that the government should assist in bringing to all the people the maximum of good reading at the minimum of cost. On this basis a postage rate was established of 1 cent a pound for periodicals to any point in the country, so that the reader at a distance from the larger cities, where publishing houses would naturally locate might have the same benefits as those near by; and this was done with full knowledge that it was an expense to the government; also that the Post Office Department at that time showed a heavy deficit at the end of each fiscal year.

Realizing the intent of the provision, reputable publishers in every line gave the readers the benefit of the low rate for transportation and established subscription prices accordingly, at an extremely low figure, so that the reader gets full advantage from the present postage rate. Financial returns on capital invested in the publishing of technical and trade papers and the better class of literary magazines are, on the average, less than in most lines of manufacturing and merchandising, so that if postage rates are substantially increased, the extra cost must of necessity be paid by the subscribers.

At the present time, according to the report of Postmaster-General Burleson, the Post Office Department is earning a surplus, yet the House Committee on Post Offices has included in the Post Office Appropriation Bill a rider establishing a zone system of postage on periodicals that runs up to 6 cents a pound for those districts lying farthest from the publishing centers. And this action was taken after only *two days'* consideration, and in spite of the fact that Mr. Burleson advocated an increase to a flat rate of only 1⅓ cents a pound, to all parts of the country.

Such a radical change as that proposed by the committee which means an average increase of 2½ times the present rate should surely have had careful and discriminating consideration of all results involved, which certainly was not possible in a two days' study of the amendment. For the great majority of the people, education in how to do things and how to think must come by reading after school days are over; only 7 out of 100 are able to remain in school beyond the grammar grade, and for the 93 who cannot, advancement must come by experience and by study of books and periodicals. Large sums are wisely spent in maintaining high schools and universities where the 7 per cent may have great advantages. But the Committee which voted to put this increased tax on ambition evidently did not favor corresponding advantages for the other 93 per cent.

The older statesmen, realizing that cheap periodicals were as truly a means of education for the great mass of the people as are the higher schools for the few, boldly cut in half the postal rate on periodicals, and gave the people the benefit. The present committee thinking only that the cost of transportation and delivery of such educational matter is for some sections greater than the postage paid, are proposing to discriminate against this means of education, and especially against those who have elected to live at a distance from large cities. And they did this on practically snap judgment and against the recommendation of Postmaster-General Burleson that the question be postponed until the effect on the spread of educational periodicals of the slight increase in rate which he advocated could be ascertained.

Mr. Randall, author of the rider amendment, estimates the average rate under the proposed system as 2½ cents a pound. And for the farthest zone, 1800 mi. or over, the added postage on Practical Engineer will be $1.25 a year, which is the tax that Mr. Randall desires to place on readers who are ambitious to improve their knowledge of power plant practice and who by choice or circumstance are at a distance from the office of publication.

We have no quarrel with honest, well-considered postal reform. There have been abuses of postal rates—such as wholesale distribution of campaign literature free under the guise of congressional reports, with which the mails are flooded, especially at election time. Also there are periodicals which serve no useful purpose, educational or otherwise; but why should the reader who wants real technical and trade information be taxed heavily, in order that the Congressman may distribute gratis seeds and pamphlets which often are not wanted by those who receive them?

And further, this rider permits *free* delivery in the county for the weekly paper — including the weekly that Mr. Randall owns—which the Congressman thinks may influence his constituents for or against his re-election. This is in spite of the fact that a large part of the circulation of the county weekly is by rural free delivery, which is the most expensive part of the service; and this fact robs the amendment of any claim to proportion the postage rate to the cost of delivery.

We are publishers, endeavoring earnestly to aid our readers in their efforts to advance. We see clearly the injustice of the provisions of the proposed amendment and the excessive tax that it will place on education for the majority of the people of this country. And we object to discrimination against readers at points distant from the great centers and who prefer the best educational periodicals they can get to the local papers. The rider contemplates a step backward in educational policy, and will work a hardship on those who are striving to overcome early disadvantages by hard personal effort.

But the remedy lies in the hands of readers who object to ill-considered class legislation and who wish to continue to enjoy inexpensive help from their professional journals. Your Congressman must hear from you with a strong protest. You should write him *today* and state your disapproval of this unwise and unjust amendment in terms that will leave no doubt in his mind as to your wishes.

## Standard Boilers

On Dec. 15, 1916, a big step toward uniform requirements for boiler construction was taken by the American Uniform Boiler Code Congress. This meeting at Washington, D. C., to which the governors of 28 states sent accredited representatives, adopted a resolution that all states should supervise boiler construction in the interest of public safety; and another recommending the adoption of the A. S. M. E. code by all states. Twenty-four states went on record as favoring both resolutions, and may, therefore, be looked to for favorable legislation. Ohio, which already had a good code, differing slightly from the A. S. M. E., will withdraw its present rules and substitute the A. S. M. E. as standard for all future works. And Massachusetts, whose Boiler Rules have been for many years the model for other states, voted in favor of the resolution and may be expected in the near future to harmonize its requirements with those of the A. S. M. E., the difference being, at present, only slight.

All the principal industrial states favored the Code, and in view of the manifest advantages of uniform requirements and the great care taken in preparing and for continuous revision to have the Code embody the best knowledge and practice to secure safe construction, it seems certain that every state will fall in line in making the A. S. M. E. Code its legal requirement, the process differing, of course, according to state constitutions and existing laws.

The Congress accomplished great work for advancing the standards of power plant practice, and Mr. Callery, who acted for the Ohio Industrial Commission in promoting the Congress, with his colleagues, are to be congratulated on the extremely satisfactory outcome of their efforts.

Resolution was also adopted favoring a uniform system of inspection, but as details of this were not in shape, the matter was referred to the Board which has in hand the periodic revision of the A. S. M. E. Code.

During the same week, the first meeting of the Code Committee for hearing suggestions as to revisions of the Code was held in New York. This was in accordance with the plan to keep the Code up to date by revision

and amendment every 2 yr., thus bringing the requirements into accord with progress in the art of boiler construction and operation.

It was notable that, at this meeting all present were in accord as to the wisdom of a uniform code, the only discussion being on details of wording or requirements. And the very eagerness of some manufacturers to have their special features approved, showed the extent to which the Code has become a recognized standard, and the realization that its requirements will, before long, be the criterion by which all boiler construction will be judged.

The principal discussion turned on permitting the use of oxy-acetylene and electric welding for seams that have to carry the strain of high pressures, and rules for capacity and installation of safety valves. Decision was, of course, reserved, but the evident desire of the Code Committee to get at all facts and be fair to all interests makes it certain that whatever is done will be after the fullest consideration and based on the best data obtainable.

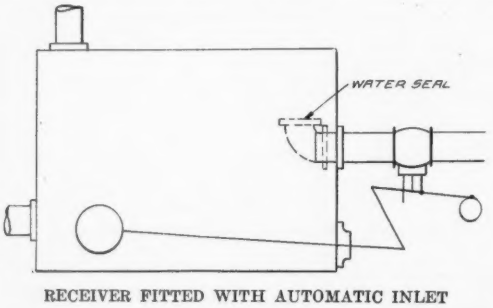
The outlook is bright for continuous progress toward country-wide uniformity in requirements for boiler construction and toward securing, so far as is humanly possible, safety in this important matter. To those who have worked long and unselfishly for the formulating of the Code and its adoption as a standard wherever regulative legislation is put into effect or whenever specifications are drawn, are due the thanks of all who have at heart the interests of the power plant industry.

# Solutions to Two Operating Difficulties

By M. A. Saller

FOR several years, it had been our custom to bring back the hot returns from a large number of our heating and drying cores to a closed receiver tank, from which they were pumped to the boilers; what little make-up water was required, was fed direct to the boiler by means of an injector.

A recent change in operating conditions, however, cut down the amount of these returns to such an extent that provision was deemed necessary for automatically admitting the make-up water. This was done by installing a float-controlled cold water connection into the receiver tank, so that the cold city water would be admitted automatically whenever the hot returns did not supply the demands; i.e., when the float dropped to a certain level.

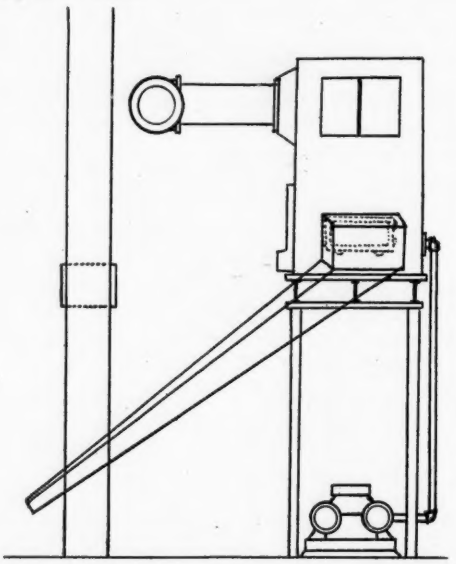



RECEIVER FITTED WITH AUTOMATIC INLET

The cold water connection into the tank was made by screwing the 1½-in. cold water inlet pipe into a similar size opening already in the tank, the pipe discharging horizontally into the tank.

Upon putting the tank in operation, we found that the opening of the cold water regulating valve and the admission of cold water through the inlet pipe was attended by severe shocks and water hammer, which we decided was due to the cold water coming in contact with the hot vapors and steam, which could work back into the admission piping, the cold water flowing along the bottom of the pipe and the hot steam at the top causing the disturbance.

As a cure for this, we decided it was necessary to water-seal the inner end of the cold water pipe. This was very simply done by screwing an elbow on the end of the pipe, with the discharge pointing up. This prevented the water from emptying entirely from the water line, hence prevented the admission of the steam which was causing the trouble. This proved to be the solution of the trouble, since the arrangement has been working perfectly ever since.



DISCHARGE CHUTE FROM CLEANOUT DOOR

In a western plant with which I was formerly connected, we had in service an open feed-water heater. This was installed between the boiler fronts and the boiler room wall, and because of the limited floor space available the heater was supported about 10 ft. above the boiler room floor on I beams and pipe supports, the boiler feed pumps being located on the floor level below. The feed water used in the plant turned out to be of poor quality, containing considerable lime. Consequently, because of the action of the steam in the heater driving off the carbonic acid gas, which held these impurities in solution, a considerable amount of deposit was found to collect in the heater bottom and along the side walls. The precipitate was so heavy and dense that the heater often clogged up in 2 or 3 weeks. The location of the heater on the elevated platform, however, made the cleaning a difficult problem to remove the heavy sludge and mud without having the apparatus cut out of service for too long a period and without slopping a considerable quantity of the precipitated matter onto the boiler feed pump below.

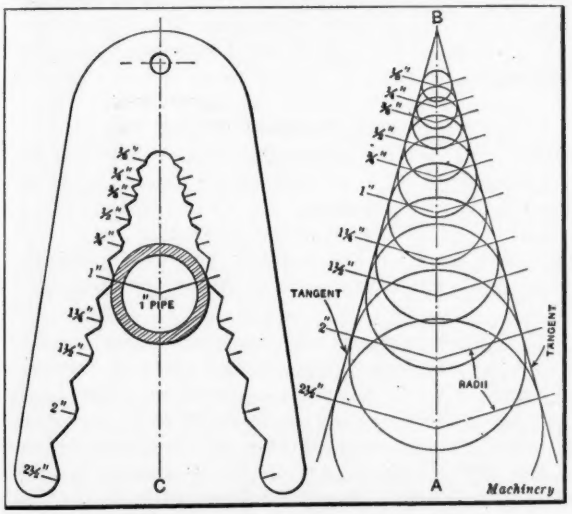
After endeavoring to remove the stuff by means of buckets, etc., we finally came around to a scheme for chuting the sludge from the heater. We therefore built a chute of wood, having a funnel arrangement at the top, which fitted up against the lower cleanout door of the heater, this chute being arranged so that it could be fastened into the same bolt-holes which held the door in place. The chute was then built long enough to carry the sludge out through the boiler room door to the yard. With this arrangement, we could clean the heater in a short time, simply bolting the chute to the clean-out opening and then using a hoe or shovel to draw the sludge from the heater into it. This chute arrangement also served to prevent the sludge from falling down on the pump below. The general layout is shown in the sketch.

# Convenient Pipe Gage

By B. Francis Dashiell

I HAVE often found, when called upon to measure up old pipe work, that considerable time is lost, especially when a number of various sized pipes are involved. The accompanying illustration shows a convenient form of pipe gage which the writer has had made and which he has found to be a great help whenever pipe sizes of any kind are to be taken.

The following method will be found convenient for laying out the gage. The two points *A* and *B* are laid out 3 in. apart on a common center line, using a piece of 1/16-in. brass or copper sheet and scribing the line carefully upon it. With the points *A* and *B* as centers,




METHOD OF CONSTRUCTING PIPE GAGE

describe two circles, respectively, 2.87 in. and 0.4 in. in diameter. These circles represent the outside diameters of the 2½ and ⅛-in. standard pipe sizes. Tangents should then be drawn to each circle, as shown, and other circles laid out on the center line, using the table of pipe sizes given herewith as a guide for the diameters. Each circle must have its circumference in the tangent, as shown in the diagram. Radii are now drawn in each circle perpendicular to the tangent, which gives the location of the various points of tangency. These points will be the points of contact for pipes of simliar size placed in the gage. After all the lines have been located, an outline can be shaped for the gage similar to that shown at *C* in the illustration. After this, the material can be cut with a hacksaw and file and the different pipe sizes can be stamped at their proper locations with steel dies. It will be found advisable to cut notches between the measuring or contact points with a file so that the pipe size can be determined easily even when operating in a dark location. If desired, the finish of the tool can be improved by polishing and nickel-plating. The gage will give any size accurately from ⅛ to 2½ in. diameter. The size of the gage is convenient and it will readily slip into the pocket.—Machinery.

STANDARD PIPE SIZES

| Nominal Size, Inches | Actual Outside Diameter, Inches | Nominal Size, Inches | Actual Outside Diameter, Inches | Nominal Size, Inches | Actual Outside Diameter, Inches |
|---|---|---|---|---|---|
| ⅛ | 0.40 | ¾ | 1.05 | 2 | 2.37 |
| ¼ | 0.54 | 1 | 1.31 | 2½ | 2.87 |
| ⅜ | 0.67 | 1¼ | 1.66 | ... | .... |
| ½ | 0.84 | 1½ | 1.90 | ... | .... |

Machinery

# Introducing Compound into Heater

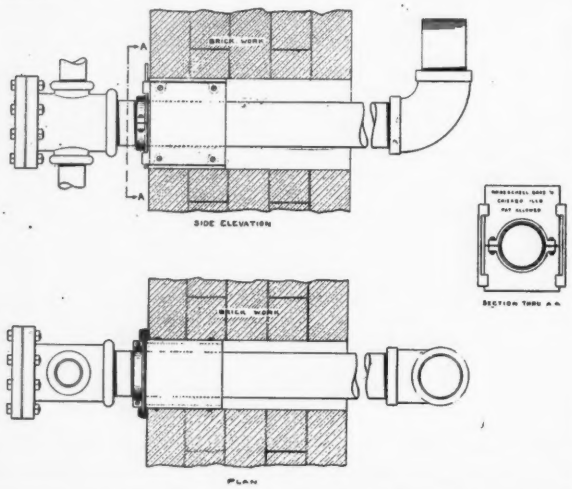
FOR some time we had been feeding compound into our boilers by injecting it into the boiler feed line between the pump and the boiler, states W. A. Lailer in Refrigerating World; but recently the water became so bad that a serious collection of soft mud and scale accumulated, causing excessive foaming and priming conditions. From the fact that we were getting no or at least very little hard scale on the tubes, we felt certain that the compound was suited for our work; but the great accumulation of soft scale sludge caused us to look about for some means of improvement.

We noticed that some little precipitate was being thrown down in our open heater, probably due to the heating of the water and driving off of the gases which held some of the impurities in solution. We also compared the water-carrying capacity of our heater with the rate at which water was being fed to the boilers and found that about 10 min. time was being allowed for the water in the heater. We therefore decided to take advantage of this settling capacity and arranged to have our compound pump discharge the solution into the heater. We at first discharged directly into the water space of the heater, but soon found that the compound was not coming in contact with all the water. We then arranged to discharge the chemical solution directly on the upper tray of the heater so that it would become thoroughly mixed with the water while passing over the trays.

After operating in this manner, we found that vast quantities of precipitate formed in our heater, which was gotten rid of by making frequent use of the blowoff valve in the bottom. In fact, the stuff removed from the heater was sufficient to relieve the boilers to such an extent that we are not troubled with scale though we know that our feed water is worse in quality than ever before.

# Relieving the Strain on Blowoff Pipe

REFERRING to article under heading "Relieving Strain on Blowoff Pipe" in the Nov. 15 issue, Chas. Kroeschell calls attention to the self-adjusting expansion box his company manufactures for that purpose. With the use of this device it is not necessary to have any packing around the blowoff pipe, this pipe being entirely free to move with any settling of the boiler.




KROESDHELL SELF-ADJUSTING EXPANSION BOX FOR BLOWOFF PIPES OF HORIZONTAL TUBULAR BOILERS

As shown, the plate which closes opening in brickwork through which the blowoff pipe extends, is made in 2 halves, so that this plate may be readily removed in order to make it possible to remove any soot or ashes that may lodge under the blowoff pipe at any time.

# News Notes

ON FEB. 8, 9 and 10, the American Association of Engineers will hold a national convention at the Hotel La Salle, Chicago, devoted largely to work of a promotional nature. Student organizations of the Association are being formed in various universities, temporary organization having been effected at the University of Illinois, Purdue University and Valparaiso. The Association has its headquarters at 29 S. La Salle St., Chicago, and reports an average growth of 100 members a month, and a good demand for structural engineers.

THE TERRY STEAM TURBINE CO., of Hartford, Conn., announces the appointment of Stephenson & Nichols, Monadnock Building, San Francisco, as its representatives in Northern and Central California and the northern part of Nevada.

P. H. REARDON, WHO has been connected with the Compressed Air & General Machinery Co., has recently established his own office at 57 First St., San Francisco, Cal., for the sale of compressed air and general machinery, mill, mine and contractors' supplies.

U. S. CIVIL SERVICE COMMISSION announces an examination, Jan. 23, for architectural draftsman, to fill a vacancy in the Office of Public Buildings and Grounds, Washington, D. C., for a period of 6 mo. and thereafter according to appropriations available, at a salary of $130 a month, and vacancies as they may occur in both temporary and permanent positions requiring similar qualifications. Prerequisites are (a) graduation from a course in architecture from a college or university of recognized standing and at least 2 yr. subsequent experience in architectural drafting or designing; or (b) for persons lacking such academic training, 2 yr. of atelier study and at least 6 yr, of such experience. Applicants must not have reached their fiftieth birthday on the date of the examination. Apply for Form 2118.

U. S. CIVIL SERVICE COMMISSION announces an examination for aid, qualified in chemistry, on Jan. 17 and 18, to fill vacancies in the Bureau of Standards, Department of Commerce, for duty in Washington, D. C., and in the field, at entrance salaries ranging from $600 to $840. Applicants must have reached their eighteenth but not their twenty-second birthday on the date of the examination. Apply for Form 1312.

U. S. CIVIL SERVICE COMMISSION announces an examination for assistant examiner in the Patent Office, for both men and women, on Jan. 17, 18 and 19, to fill vacancies as they may occur at the entrance salary of $1500, in the U. S. Patent Office, Washington, D. C. Age, 20 yr. or over on the date of the examination. Apply for Form 1312, and a copy of the Manual of Examinations for the fall of 1916, stating the title of the examination desired, to the U. S. Civil Service Commission, Washington, D. C.

U. S. CIVIL SERVICE COMMISSION announces an examination, Jan. 16, for supervising mining engineer and metallurgist, to fill a vacancy in the Bureau of Mines, Department of the Interior, for service in the field, at a salary of $4000, and vacancies as they may occur. Applicants must not have reached their fiftieth birthday on the date of the examination. Apply for Form 2118.

U. S. CIVIL SERVICE COMMISSION announces an examination for surveyor, on Jan. 17 and 18, to fill vacancies in positions of U. S. surveyor and transitman in the General Land Office, and vacancies as they may occur in positions requiring similar qualifications in any branch of the service. Age, 19 yr. or over on the date of the examination. Apply for Form 1312.

U. S. CIVIL SERVICE COMMISSION announces an examination for electrical draftsman, to fill several vacancies in the Navy Department, Washington, D. C., at salaries ranging from $3.52 to $6 a day, and vacancies as they may occur in positions requiring similar qualifications in the department at Washington or at any navy yard or other naval establishment of the United States. Until further notice, and on account of the urgent needs of the service, applications will be received at any time and the papers will be rated immediately upon their receipt, in order that appointments may be made with

the least possible delay. Competitors will not be required to report for examination at any place, but will be rated on education, preliminary training and experience. Applicants must have had the equivalent of a high-school education and 4 yr. practical experience in drafting, of which 2 yr. have been employment in electrical drafting; or a degree in engineering from a technical school of recognized standing and 1 yr. additional practical experience in electrical drafting. It is desirable that the drafting experience required be of a marine electrical character such as may be acquired in the electrical department of a shipbuilding company, at whose plant battleships, torpedo-boat destroyers, or submarines are built, or in some U. S. naval establishment, but this experience is not absolutely necessary. Additional credit will be given, however, for marine experienee of the kind specified. Applicants must have reached their eighteenth birthday on the date of making oath to the application. Apply for Form 1312.

TO EXTEND and strengthen the field of its graduate work in engineering, the University of Illinois maintains 14 Engineering Experiment Station Research Fellowships. One other such fellowship has been established under the patronage of the Illinois Gas Association. These fellowships, for each of which there is an annual stipend of $500.00, are open to graduates of approved American and foreign universities and technical schools. Appointments to these fellowships are made and must be accepted for 2 consecutive collegiate years, at the expiration of which period, if all requirements have been met, the degree of Master of Science will be conferred. Not more than half of the time of the Research Fellows is required in connection with the work of the department to which they are assigned, the remainder being available for graduate study.

Nominations to these fellowships, accompanied by assignments to special departments of the Engineering Experiment Station, are made from applications received by the Director of the Station each year not later than Feb. 1. The nominations are made by the Station Staff, subject to the approval of the Executive Faculty of the Graduate School and the President of the University. Nominations are based upon the character, scholastic attainments and promise of success in the principal line of study or research to which the candidate proposes to devote himself. Preference is given those applicants who have had some practical engineering experience following their undergraduate work. Appointments are made in the spring and they take effect the first day of the following September. Vacancies may be filled by similar nominations and appointment at other times.

The Engineering Experiment Station, an organization within the College of Engineering, was established in 1903 for the purpose of carrying on investigations in the various branches of engineering, and for the study of problems of importance to engineers and to the manufacturing and industrial interests of the State. Research work may be undertaken in architecture, architectural engineering, ceramic engineering, chemistry, civil engineering, electrical engineering, mechanical engineering, mining engineering, municipal and sanitary engineering, physics, railway engineering, and in theoretical and applied mechanics.

The work of the Station is closely related to that of the College of Engineering, and the Heads of Departments in the College constitute the administrative Station Staff. Investigations are carried on by members of the Station Staff and other members of the instructional staff of the College of Engineering, by special investigators employed by the Station, and by the Research Fellows.

Additional information may be obtained by addressing The Director, Engineering Experiment Station University of Illinois, Urbana, Ill.

# Catalog Notes

DR. CHAS. A. LAUFFER, Medical Director of the Westinghouse Elec. & Mfg. Co., East Pittsburgh, has recently delivered before medical societies, safety-first and welfare conferences, a series of papers dealing with disease and accidents in industrial plants, that have been favorably commented upon by the medical profession. Among these papers is one on the subject of "Sickness versus Accident," in which the author draws the conclusion, based on a wide experience in the Westinghouse plant, of the tendency of the employe to attribute ailment to accident rather than to sickness, thereby making the company liable for compensation damages which would not be the case were the ailment to be due to sickness. Dr. Lauffer has also presented papers on the subject of "Hernia" as an anatomical defect rather than an accident, and produces evidence from his own experience as well as letters from a number of prominent physicians to substantiate his arguments.

THE LAGONDA MFG. CO.'S latest bulletin, which is devoted to the subject of Lagonda cleaners for locomotive arch tubes, discusses the formation of scale in arch tubes, and shows the construction and illustrates the standard sizes of air, steam and water driven arch tube cleaners. Railroads have found out that it pays to clean arch tubes periodically, and it is becoming good practice to clean them every time the boiler is washed out, which is generally once a week; stationary engineers might find a lesson in the railroads' experience.

Bulletin W-3 will be sent on request to those parties interested who address the company at Springfield, O.

ENGINEERS, steam fitters, etc., whose duties include the laying out and installation of piping systems will find much valuable information relative to offset measurements of fittings on a card, convenient for vest pocket or desk use, prepared and distributed by Kroeschell Bros. Co., 440 W. Erie St., Chicago. A postcard with your name and address will bring a copy.

AMONG THE PUBLICATIONS recently issued by the Westinghouse Electric & Mfg. Co., are a series of leaflets covering meters and relays of various types, including d.c. meters of small diameter for use on automobiles, portable voltmeters and ammeters for testing purposes, and type CO overload and CR reverse power a.c. relays. These instruments are thoroughly illustrated and described in leaflets 3949, 3950 and 3814, respectively.

A NEW CATALOG of a complete line of hose manufactured by Peerless Rubber Manufacturing Co., 31 Warren St., New York, has just been issued.

THE CLING-SURFACE CO., 1028 Niagara St., Buffalo, N. Y., has issued a unique calendar of special interest to engineers and will gladly send a copy to anyone who applies to them for it.

GEORGE McDOWELL'S improved Berryman feedwater heater and purifier, made by The F. W. Horstmann Co., 196-210 Coit St., Irvington, N. J., is the subject of a pamphlet recently received.

BULLETIN NO. B-3000 of Yeomans Brothers Co., 231 Institute Place, Chicago, illustrates and describes Yeomans electric single and duplex bilge pumps for automatically raising surface water, drainage and sewage in basements below the level of street sewers and municipal sewerage systems.

## Trade Notes

THE FIFTH FURNACE at the Belmont plant of the Link-Belt Co., Indianapolis, was blown in the middle of December, adding materially to the capacity for producing malleable Link-Belt. Extensive building operations at the Belmont works have been completed, and the manufacturing activities reorganized to keep pace with the increased demand for Link-Belt for all conveying, elevating and power transmission purposes.

THE FOLLOWING ORDERS of switchboard apparatus for the initial equipment of new generating stations are among those recently placed with the Westinghouse Electric & Mfg. Co.: Union Gas and Electric Co., Cincinnati, O., new West End power house, initial capacity 62,500 kv.a., 3-phase, 60-cycle, 13,200 v., ultimate capacity 287,000 kv.a., and 1 4-section control deck; 1 14-panel, 3 5-panel, 2 2-panel switchboards, 8 2000-amp. type 0-2, and 58 type E-6 oil circuit breakers; Buffalo General Electric Co., Buffalo, N. Y., New River steam station, initial capacity 66,666 kv.a., 3-phase, 25-cycle, 12,000 v., ultimate capacity 233,000 kv.a., 1 8-panel, 1 6-panel, 1 5-panel and 1 3-panel switchboard, 12 2000-amp., type 0-2 and 17 600-amp., type 0-1 oil circuit breakers; Dayton Light and Power Co., Dayton, O., new Millers Ford generating station, initial capacity 31,250 kv.a., 3-phase, 60-cycle, 6600 v., ultimate capacity 125,000 kv.a., 1 7-section control desk, 1 10-panel, 1 8-panel and 1 3-panel switchboard, 10 type 0-2, 13 type E-6, 16 type E-8 oil circuit breakers; Montana Power Co., Holter Junction, Mont., new Holter Hydro-Electric Development, initial and ultimate capacity 48,000 kv.a., 3-phase, 60-cycle, 6600 v., 1 7-panel, 1 6-panel, and 3 5-panel switchboards, 11 type E-6, and 7 110,000-v. type GA oil circuit breakers; Public Service Co. of Northern Illinois, Joliet, Ill., new No. 9 power station, initial capacity 12,500 kv.a., 3-phase, 60-cycle, 12,000 v., ultimate capacity 50,000 kv.a., 1 2-section control desk, 1 9-panel, 1 5-panel, and 3 4-panel switchboards, and 6 type GB oil circuit breakers.

PRACTICAL ENGINEER

Trade-mark, Reg. U. S. Pat. Off.

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SEMI-MONTHLY

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Full page, one year, each insertion, $66.00.

Half page, one year, each insertion, $38.50.

Quarter page, one year, each insertion, $22.00.

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Front cover, $175.00 per issue.

Other specified positions, regular rate plus 10 to 50 per cent.

Stippled plates used, but no heavy, black and white plates.

### Classified Rates

Per line, 30 cents each insertion.

Advertisements in this section are inserted under regular headings.

No display type allowed, but the first three words may be set in capital letters.

About nine words make a line. Minimum space sold, two lines.

Under classification "Position Wanted," advertisements not exceeding four lines will be inserted once for subscribers free of charge.

All copy should be received at Chicago office 18 days before date of publication.

Circulation of this issue, 22,500.

**Technical Publishing Co.**

537 S. Dearborn Street

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**Position Wanted**

POSITION WANTED—I am a thoroughly competent power plant engineer, accustomed to handling on high efficiency basis all types of steam engines and turbines, A.C. and D.C. machines; strictly sober; 34 years old, married. Want charge of good plant in Chicago that will pay at least $25.00 per week. Address Box 455, Practical Engineer, 537 S. Dearborn St., Chicago. 12-15-2

STEAMFITTER—Accustomed to high pressure work wants permanent situation. American and strictly sober always; am not afraid of plenty of work. Can work from blue prints, as well as do all kinds of general repairs. Have some experience in millwright work and some knowledge of steam engineering. H. L. Simonds, Box 166, Sac City, Iowa.

POSITION WANTED—As oiler, by young man, age 21, single. Willing to accept position in any city. Address Peter Stanys, 670 W. 18th St., Chicago, Ill. 12-1-3

## Help Wanted

WE WANT A SALES ENGINEER or first-class Specialty Salesman to represent us in different localities for the sale of a mechanical device for boilers for which there is a universal demand. Interested only in man now actually covering and soliciting power plant field, who has some general knowledge of boilers and who will tell in first letter what he is selling. A liberal commission insuring adequate compensation but only to desirable man. Be explicit regarding territory. Address Box 459, Practical Engineer, 537 S. Dearborn St., Chicago, Ill. 11-1-3-e.o.1

WANTED—Resident subscription agents in the following cities: Atlanta, Ga.; Cincinnati and Columbus, Ohio; Kansas City, Mo.; Los Angeles, Cal.; Louisville, Ky.; Newark, N. J.; New Orleans, La.; Portland, Ore.; St. Louis, Mo.; San Francisco, Cal; Washington, D. C. This is an excellent chance for a hustler who is familiar with power plant conditions, to turn his spare time into dollars. To such a one we offer a Real Opportunity. Write Subscription Department, Practical Engineer, 537 S. Dearborn St., Chicago, Ill. tf.

WANTED—Operating engineer, familiar with central station plant, which consists of all modern equipment; a knowledge of high tension transmission line operating is essential. A splendid opportunity for the right man, with a rapidly growing company. State age, reference, education, salary expected. Box 461, Practical Engineer, 537 S. Dearborn St., Chicago, Ill. 1-1-1

WANTED—Experienced men for outside erection of power plant equipment, including boilers and mechanical stokers. Give age, experience and references. Box 462, Practical Engineer, 537 S. Dearborn St., Chicago, Ill. 1-1-1

## Wanted

WANTED—Agents handling engine and boiler room specialties in every section for side line paying large commissions. Give experience, line carried and territory covered. Box 381, Practical Engineer, 537 S. Dearborn St., Chicago, Ill. tf.

WANTED—The following numbers of Practical Engineer: Feb. 1, Feb. 15 and March 1, 1912; April 1, 1913, and all of the year of 1914. H. G. Hewitt, 386 Division St., Amsterdam, N. Y. 1-1-1

FOUR COPIES of Practical Engineer for February, 1910, in good condition: we will extend your subscription for three months. Circulation Department, Practical Engineer, 537 S. Dearborn St., Chicago, Ill.

WANTED—Agents on commission to sell our shaking grates. We will install grates on trial or put it on test at our expense with any grate made. Address Armstrong Mfg. Co., Springfield, Ohio.

MARINE BOILERS WANTED—From 50 to 250 horsepower. We will pay cash awards for information that leads to a purchase. The Pittsburgh Boiler & Machine Co., Pittsburgh, Kans. 1-1-6

WANTED—Machine work or building; modern plant and foundry; J. & L. equipment; medium and light punch press work. The Challenge Machinery Company, Grand Haven, Mich. 1-1-4

## For Sale

FOR SALE—Robertson Thompson Steam Engine Indicator. Reducing Motion, Three Way Cock, etc. In A1 condition. Box 464, Practical Engineer, 537 S. Dearborn St., Chicago, Ill. 1-1-1

FOR SALE—260 h.p. Sterling watertube boiler. Insured 150 lbs.; $1,000. 30 k. w. G. E. 125 volt generator, dir. con. Skinner engine, $600. 100 k.w. W. E. 250 volt generator, direct con. Ridgeway engine, $1,300. Power Machinery Exchange, 1 Montgomery St., Jersey City, N. J. 1-1-1

FOR SALE—One 40 horsepower horizontal boiler, one 40 horsepower steam engine, one 30 horsepower steam engine, one 20 horsepower steam engine, one 25 horsepower gasoline engine, one 10 kilowatt generator, one 2½ kilowatt generator. N. E. Martin, Leola, Pa. 1-1-1

FOR SALE—One Westinghouse Locomotive type Air Compressor, 8"x9"x10" stroke, good for 75 lbs. air pressure, including a new set of piston rings. Price $25.00. Communicate with Chief Engineer, W. L. Doughlas Shoe Co., Brocton, Mass. 1-1-1

FOR SALE—One Type M. P. 8 Pole 200 k.w. 210 r.p.m. 225 to 250 volt G. E. Generator direct connected to tandem compound Ideal Engine. Class A condition. Box 465, Practical Engineer, 537 S. Dearborn St., Chicago, Ill. 1-1-1

FOR SALE—De Laval steam turbine, type R. D., 200 pounds pressure, connected to 2 75 k.w. D .C., 115 volt, 900 speed Western Electric generators, all in good condition. $2,000.00. Box 463, Practical Engineer, 537 S. Dearborn St., Chicago, Ill. 1-1-1

GAS ENGINE FOR SALE—One 15-hp. 2-cylinder Westinghouse gas engine for sale in good condition. No reasonable offer refused. Correspond with E. B. Latham & Co., 4 Murray St, New York City. 10-15-6

## Patent and Patent Attorneys

PATENTS THAT PROTECT AND PAY—Advice and books free. High references. Best results. Promptness assured. Send sketch of model for search. WATSON E. COLEMAN, Patent Lawyer, 624 F St., N. W., Washington, D. C. tf.

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PATENTS—H. W. T. Jenner, Patent Attorney and Mechanical Expert, 606 F St., Washington, D. C. Established 1883. I make a free examination and report if a patent can be had and the exact costs. Send for full information. tf.

A. P. CONNOR, Consulting Electrical and Mechanical Engineer, Attorney-at-Law and Solicitor of Patents and Trade-Marks. Results guaranteed. 121 Carroll St., S. E., Washington, D. C. tf.-x

PATENTS—Send sketch for free search and reports. Books and patents and book of reference letters sent free. John S. Duffie & Co., 612 F St., Washington, D. C. tf.

PATENTABLE IDEAS WANTED—Send for three free books. R. B. Owen, 28 Owen Bldg., Washington, D. C. tf.

## Technical Books

FREE ENGINEER BOOKS and power plant tools and specialties, for securing new subscribers to Practical Engineer. A dandy chance for the engineer with a little spare time, to get some fine premiums. Send for free descriptive circular and terms. Subscription Department, Practical Engineer, 537 S. Dearborn St., Chicago, Ill.

## Miscellaneous

ENGINEERS—Get the Nold Valve Reseating Machine if you want the best service when reseating valves. The cutting tools can be adjusted to any length desired, giving ample clearance in the body of the valve. A convenient, true guide is furnished for upper end of tool. This machine represents a small investment and saves piles of money. Write for full facts NOW. The Nold Valve Reseating Tool Co., 500 Fraser St., Bay City, Mich.

ENGINEERS, DO YOU WANT to utilize your exhaust steam for heating or drying purposes without back pressure on your engine? If so, address Monash Engineering Co., 1413 W. Jackson Blvd., Chicago, Ill. tf.

# Sparks From The Advertising Pages

## 1917—Make It a Year of Great Achievement in Personal Development.

This is the time of inventories, trial balances, the recording of material assets—a season in which many manufacturers sum up their stock in trade. It is also a most opportune time to make a trial balance of your intellectual assets. January will always be the time of resolutions—new inspirations—because the New Year is begun with a clean slate—a fresh start—a new program—our vision being made more keen by the mistakes and follies of the past year.

At this time of serious reflection, when you measure the distance to success, you can't overlook the golden moments frittered away last year—moments that could have been used for self-improvement—the study of the many ways to increase personal and plant efficiency. It has been estimated by one who knows investing only 15 minutes a day in the reading of one subject will make you a master of that subject in a few years, provided you read to assimilate. The hitch lies in the provision, "reading to assimilate." Skipping and scanning should be supplanted by a systematic and consistent reading, rereading and filing for future reference.

That information having a direct bearing upon our work is of first importance. Practical Engineer should, therefore, occupy first place in your reading program. Every page, editorial and advertising, should be read carefully to locate the facts dealing with the principle, the construction and the operation of power plant equipment—and then read and reread before filing for future reference.

Follow the practice of successful men in the engineering field and you will invariably find that this is their method of procedure. Every announcement in the advertising section is used as an index to the advertiser because the readers know they are safe to do business with the man who advertises. And they find the advertising section forecasts the future of power plant practice. Just as soon as a new mechanical device has passed the test of commercial usefulness the next step is to give it publicity and the man who studies the advertising pages is well posted on the latest and best equipment offered the industrial world.

It is, therefore, obvious that the study of the advertising section is of prime importance in stimulating success. Practical Engineer wishes you the maximum success in making 1917 a year of great achievement in personal development.